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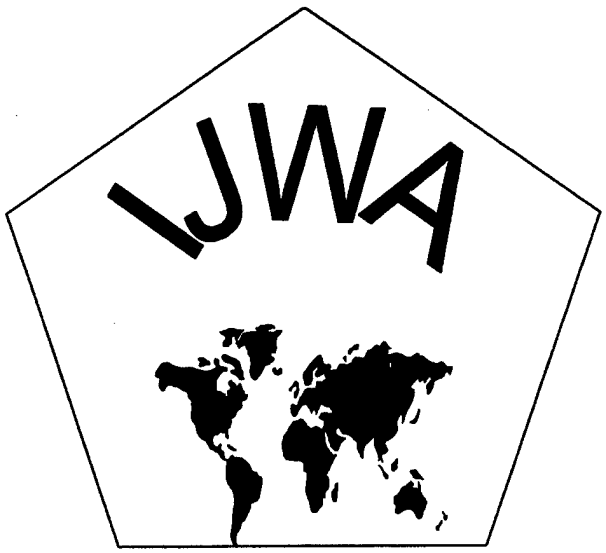
OBJECTIVE DATA FROM FLEET BATTLE EXPERIMENT FOXTROT, GOLF, AND HOTEL



Nelson Irvine

January 2001

The Institute for Joint Warfare Analysis
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This document presents the collected reports and analysis of the objective data from FBE F, FBE G, and FBE H and shows the increased scope of objective data collection with the progression of this sequence of experiments.

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Introduction

This document collects together the reports and analyses of the objective data from FBE F, FBE G and FBE H. The objective data are primarily quantitative and, whenever possible, were collected electronically for post experiment analysis. A primary objective of the objective data analysis is the construction of engagement time lines that detail the intervals required for each discrete step in the engagement process from initial target sensing until BDA is reported. To realize this objective requires that each event in the engagement process is logged, time tagged and the associated relevant engagement parameters recorded.

This sequence of experiments shows the increasing scope of objective data collection. In FBE F, the analyzed data were limited to the displays captured in LAWS, the central component of the Digital Fires Network (DFN). LAWS has remained the primary source of objective data through all the experiments. Unfortunately, there are many data elements that never appear or are frequently missing from the LAWS timelines. The deficiencies in the LAWS data are described on pages 8 and 49.

In FBE G, the LAWS data, were supplemented by event data from the JTW/PTW+ systems. Although JTW/PTW+ data were collected for all targets nominated for mensuration, these data were manually collected and suffer from the inaccuracy inherent in this process. Data were also collected from RMS. However, the received RMS data were summary statistics (e.g. mean and median times for route creation), not event data for each individual engagement.

In FBE G, Internet Relay Chat (IRC) communications were logged and time tagged. Experiment participants used approximately 10 IRC channels as a primary collaborative tool. Strictly speaking, the IRC data are not objective, but they are an important source of qualitative data. In FBEs, qualitative data collected include: observations made during the course of the experiment by observers located at critical nodes in the digital fires and command and control networks, notes and reports made by participants, interviews with participants conducted post-trial and IRC. The objective event data collected at the DFN component systems allow the quantitative characterization of the complete engagement process. The comprehensive analysis of FBEs requires both the qualitative and quantitative data – the quantitative data to accurately define what happened, the qualitative data to provide the context for the events and the why.

In FBE H, the objective data collection moved closer to the ideal of a completely characterized engagement timeline. In this experiment, complete event data were collected for each RPM generated TLAM/TTLAM route and the GISRC workstations captured acquisition and nomination event data for many targets.

Even though the number of systems from which data are being collected has expanded through the sequence of experiments, there are still systems from which data have not been obtained and for those systems which have provided data, incomplete data collection is unfortunately the norm. Page 76 summarizes, for FBE H, the specific event

data that were sought, what were obtained and why certain data were not successfully collected. In addition to missing system event data, the analysis of FBE objective data has been compromised by the lack of time synchronization among the component DFN systems.

ANALYSIS OF OBJECTIVE DATA FBE F

Time Critical Targets (TCT) in FBE-F

This report presents data relating to TCTs in FBE-F based on an analysis of the LAWS data collected from the LAWS server on the JFK. The primary assumption underlying this analysis is that all of the targets presented in the LAWS Mission Coordination: Fires list were TCTs. GISRS-M, which nominated about one third of the targets in the list, confirms that all their nominations were TCTs. The principal broad conclusions drawn from the analysis are listed below.

1. About half the TCT nominations were engaged.
2. Of the targets engaged, about one third were engaged with MLRS.
3. Of the targets not engaged, about half may not have been engaged as result of inadequate time, data or resources.
4. For those targets with sufficient timeline data on which to base a conclusion, almost no targets were engaged within the specified target dwell time.
5. There does not appear to be much relation between the experimentally observed sensor to engagement threads and the 16 TCT threads defined in the Fleet Battle Experiment Foxtrot Fires and Precision Engagement Roadmap.
6. The LAWS data contain many voids.

Each of these points is discussed in more detail below.

TCTs Engaged.

The LAWS Fires mission list contained 218 targets. Of these, 14 targets (nominated by C5F LAWS and JPJ LAWS) were deleted because the target description contained the word "test". In addition, 28 targets received at LAWS prior to December 4 (all nominated by PTW+) were deleted, leaving a sample of 176 targets. A target was defined as fired on if the Fired Status block (the FRD column) in the Mission Coordination: Fires table was green. A green FRD block indicates that the LAWS terminal received an acknowledgement from the firer that the mission was fired. Other targets, which do not exhibit this condition, were also considered to be fired on. In the sample of 176 targets there are three that have a red block labeled NAK (not acknowledged) in the FRD column. This means that the mission timed out without receiving an acknowledgement from the firer that the mission was fired. There were a further seven missions that are yellow in the FRD block. For unknown reasons, these blocks did not time out (were not turned red). Those targets that are yellow or red in the FRD block may have been fired on and for the purposes of this analysis they are presumed to have been fired on. Finally, there are six TACAIR missions listed as flown but only one of which shows a green FRD block. These targets are also presumed to have been fired on. Operating under these assumptions, 93 (53%) of the 176 TCTs critical targets were fired on. GISRS-M was the nominator of 72 (41%) of the 176 targets. The data for GISRS-M nominations are more complete and considered to be more reliable than for the sample as a whole. Accordingly, the GISRS-M data will be

looked at independently of the data summed over all nominators. For GISRS-M, 28 of its 72 nominations (39%) were fired on.

TCT firers.

Table 1 provides a breakdown of the weapon types employed against the TCTs that were fired on. It is emphasized that these data apply only to the engaged targets. In some cases, the targets that were not engaged were matched with specific firers. These unprosecuted matchings are not contained in **Table 1**. Almost half of the 93 targets engaged (44%), were engaged with MLRS. For the GISRS-M nominations, 32 percent of the engaged targets were engaged with MLRS.

TCTs not Engaged.

Table 2 presents those TCTs not fired on and gives a breakdown of the reasons why the targets were not fired on. In many cases, the LAWS Mission Coordination: Fires table provides the reason for not firing the mission in the form of a three letter indicator displayed on a red or cyan Element Approval block (the TGT column). In some cases, the remarks or other data in the LAWS Viewing Fire Mission/Targeting Information window provided a plausible reason the target was not engaged. Below, these reasons have been divided into four classes:

1. Not a desirable target.
   a. Dumb target (DMB).
   b. Redundant target. Target already being processed (RUT).
   c. Not High Value. Does not meet attack guidance (NHV).
   d. Target killed (KILL).

2. Operational constraints.
   a. Effects not achieved. Weapon system not effective (ENA).
   b. Target in a no fire area (NFA).
   c. Route in conflict (RTE).
   d. Friendlies in area (FRD).
   e. Restricted fire area (RFA).
   f. High target speed (SPD).
   g. The nominator defined the Not Later Than (NLT) time as equal to the acquisition time (N=A).

3. Denied (DEN)
   These missions were denied for unspecified reasons. If more information were available they would probably fall into classes 1 or 2.

4. Deficiency of data, time or resources.
   a. Past intelligence cutoff time or additional target intelligence required (INT).

b. Require mensuration data (MEN).
c. No known reason for not engaging (?).

It is assumed the targets in this class 4 were not prosecuted due to a deficiency of time, target information or resources. As table 2 indicates, about half (57%) of the targets defined as not fired on fall into class 4. The corresponding figure for the GISRS-M nominator is 52%.

Timelines.

In principle, LAWS provides the data to create a timeline for each TCT mission. The LAWS Viewing Fire Mission/Targeting Information window has data fields for acquisition time and No Later Than (NLT) time. In addition, the LAWS Mission Timeline Report reports (ideally) and provides a time tag for a number of events in the process of prosecuting a TCT. These include: The time the target nomination was received at the LAWS server (At FSC), the time at which the fire when ready command was transmitted from LAWS to the fire direction system (the XMT When Ready event) and the receipt of a confirmation that the mission has been fired (the Fired Report event). Unfortunately, in many instances, one or more of these events and associated times are missing, or are in error, for missions that otherwise appear normal. Although the Mission Coordination: Fires lists contains 93 missions that have been defined as fired, the majority of these had insufficient data to construct a complete mission timeline.

Figure 1 presents a histogram of the interval from acquisition time until the nomination was received at the LAWS server for missions that were fired.

Figure 2 presents a histogram of the interval from receipt of the target nomination at the LAWS server until fire. To provide the fire time, the ideal would be to use the Fired Report time from the firing unit. However this time was lacking or in error (particularly for MLRS firers) in the majority of cases. Consequently, the time of the XMT When Ready event was often adopted as the fire time.

Figure 3 presents the interval from acquisition to fire. The times in **Figure 3** under represent the time for a projectile to reach the target because many use the XMT When Ready event time to represent the fire event time, and they do not include the projectile time of flight to the target.

Figures 1A, 2A and **3A** are the same plots as the corresponding plots described above except they are limited to the targets developed by the GISRS-M nominator for which the data are generally more complete and reliable. **Table 3** below summarizes the timeline data.

TABLE 3. TIMELINE DATA

FIGURE	# ENTRIES	MEDIAN TIME (MIN)
Acq-LAWS Interval (Fig. 1)	46	28
Acq-LAWS Interval GISRS-M (Fig. 1A)	27	18
LAWS-Fire Interval (Fig. 2)	61	33
LAWS-Fire Interval GISRS-M (Fig. 2A)	15	16
Acq-Fire Interval (Fig. 3)	28	119.5
Acq-Fire Interval GISRS-M (Fig. 3A)	15	75

Not Later Than Time (NLT)

The success of an engagement against a TCT must be judged, in large part, on whether the target was engaged within the specified target dwell time. There were 23 missions that were fired and for which an NLT time was specified. For those 23 missions, only in one case was the mission fired within the target dwell time, in 18 cases it was not. In four cases there are insufficient data to determine if the time constraint was met.

Time Critical Targeting Threads

Tables 4 through **8** present the sensor to engagement threads for time critical targets for each target nominator. These data apply to the 93 missions previously defined as fired. The target type, acquiring sensor and munition fired data were collected from the LAWS Viewing Fire Mission/Targeting Information window. The primary points to be made regarding these data are:

1. There does not appear to be much relation between these experimentally observed threads and the 16 TCT threads defined in the Fleet Battle Experiment Foxtrot Fires and Precision Engagement Roadmap (section 19).

2. The LAWS data lack specificity. One sensor is defined as ELINT but which type of platform mounted the sensor is unidentified. Another "sensor" is Photo Interpretation (PI) but there is no indication what the original source of the image was.

3. The Engagement thread data reported by the LAWS nominators (C5F, JFK, JYG and DOCC) was incomplete. In particular, in almost no case was the acquiring sensor specified.

4. The LAWS operator and/or nominators do not use standard terminology. For example, in a number of cases target type is referred to as SSM. The remarks indicate this target type is used to apply to ballistic missiles, cruise missiles and surface to air missiles.

Data Capture Recommendations

This analysis was entirely dependent on the data collected through LAWS. LAWS has the potential for providing detailed quantitative data, particularly in the development of time lines of the events in the process of prosecuting TCTs. However, in practice the data have been found to be rather incomplete. It is understood that the data collection potential of LAWS depends on a combination of operator training and software modifications to LAWS and/or the simulations with which it interacts. Listed below are some specific issues.

1. Some Mission Timeline reports lacked XMT When Ready events. This could occur even when, in the Mission Coordination: Fires table, the Fire Mission Status block (WRD) was yellow or green. When the WRD block is yellow or green there should be a transmit fire command event in the timeline.

2. Some missions that were presumably fired, lacked a Fired Report event. This, at least in some cases, is a result of the fact the firings are simulated and often the firers are simulated. This problem may be addressable by having a more responsive simulation.

3. For many MLRS missions, the Fired Report times as reported in the timelines were in error, being days or many hours after the XMT When Ready event. A large number of these erroneous Fired Reports had times within a few seconds of 7 Dec 13:48 (local time).

4. Many missions had no acquisition time reported in the Viewing Fire Mission/Targeting Information window. The nominator/LAWS operator must enter the acquisition time.

5. Most missions did not have a NLT time reported in the Viewing Fire Mission/Targeting Information window. The nominator/LAWS operator must enter the NLT time.

6. Many targets nominated by the CF5 LAWS nominator contained the word "test" in the target description. These targets were excluded from the above analysis. It is suspected that there are other test cases that were not so indicated. Operators need to ensure that all targets that represent practice events are clearly distinguished from those that relate to the MSEL events.

7. It would be helpful to expand the event data reported in the Mission Timeline report to routinely include other event data, e.g., acquisition time, expected time to engage, receipt of mensuration data, and receipt of route data.

8. The target priority specified in the LAWS Mission Coordination: Fires table bears no relation to the target priorities in the Attack Guidance Matrix. A uniform definition of priority should be established.

9. In only two of the seven cases where a target was denied because it was redundant (RUT) was the target it was redundant with identified. The operator should always specify the redundant target.

10. There are cases where TGT is not green (e.g. GS0070 = reviewed blue, GS2127 = denied RUT, PT0214 = red) but FRD is green. It is presumed these are cases where the LAWS operator chose to override the review or denial. It would seem less confusing if the fire override automatically changed TGT to green.

11. There are cases where there is no denied or reviewed condition exhibited in the Mission Coordination: Fires table, but in the Viewing Fire Mission window, the Reason field, which displays the reason for a denial, contains a value (e.g. LE0034, Not High Value; JS0108, Intelligence). This appears to be an inconsistency.

12. There are a several cases where the mission was fired but the LAWS data contain no information on the identity of the firer. It is understood that for MLRS missions the specific fire unit and munition are specified by AFATDS and it is not known to LAWS, but in the FBE-F Mission Coordination: Fires table many MLRS missions do have firer and munition data. The operator should at least specify the mission is MLRS.

13. Most of the JSOTF nominated targets had acquisition times entered only as hr:min. Operators should specify all times in dd:hh:mm .

14. All times should be expressed in the same reference frame. At present, the acquisition and NLT times are reported in the Viewing Fire Mission/Targeting Information window in Zulu time. The Mission Timeline report gives event times in local time.

15. The nominators/LAWS operators need to be more specific with regard to the sensors acquiring a target. ELINT and PI are too generic, at least the platform type that the acquiring sensor is mounted on should also be identified.

16. The nominators/LAWS operators need to develop a standard terminology for the LAWS data fields. In particular, target type and acquiring source.

TABLE 1. FBE-F TCTS FIRED ON

NOMINATOR	# TARGETs	#TARGETS FIRED ON	FIRER TYPES					
			MLRS	TTLAM	ERGM	LASM	TACAIR	UNKNOWN
1 CAV 2BDE	5	0						
GISRS-M	72	28	9	7	1	3	4	4
JSWS	19	7	5		1	1		
C5F LAWS	10	7	1		4			2
JFK LAWS	7	4			2	2		
JYG LAWS	2	2			2			
DOCC LAWS	20	20	18					2
PTW+	22	17	8	3		4	2	
JSOTF	19	8		2		5	1	
TOTALS	176	93	41	12	10	15	7	8

TABLE 2. FBE-F TCTS NOT FIRED ON

		#TARGETS	NOT DESIRABLE				OPERATIONAL CONSTRAINTS								LACK DATA		
NOMINATOR	# TARGETs	NOT FIRED ON	DMB	RUT	NHV	KILL	ENA	NFA	RTE	FRD	RFA	SPD	N=A	DEN	INT	MEN	?
1 CAV 2BDE	5	5															5
GISRS-M	72	44	4	3	4	1	1	1	2			3	2		7	3	13
JSWS	19	12				1			1						6		4
C5F LAWS	10	3		1													2
JFK LAWS	7	3		1											1		1
JYG LAWS	2	0															
DOCC LAWS	20	0															
PTW+	22	5			2				1					1			1
JSOTF	19	11		2	3					1	1				1	1	2
TOTALS	176	83	4	7	9	2	1	1	4	1	1	3	2	1	15	4	28
			TOTAL=22				TOTAL = 13							1	TOTAL = 47		

DMB = Dumb target

RUT = Redundant target. Target already being processed

NHV = Not high value. Does not meet attack guidance

KILL. Remarks in the Targeting Information window indicate the target has been killed.

ENA = Effects not achieved. Weapon system not effective

NFA = No fire area

RTE = Route in conflict

FRD = friendlies in area

RFA = restricted fire area

N = A. The LAWS Targeting information window gives target acquisition times and Not Later Than times that are identical

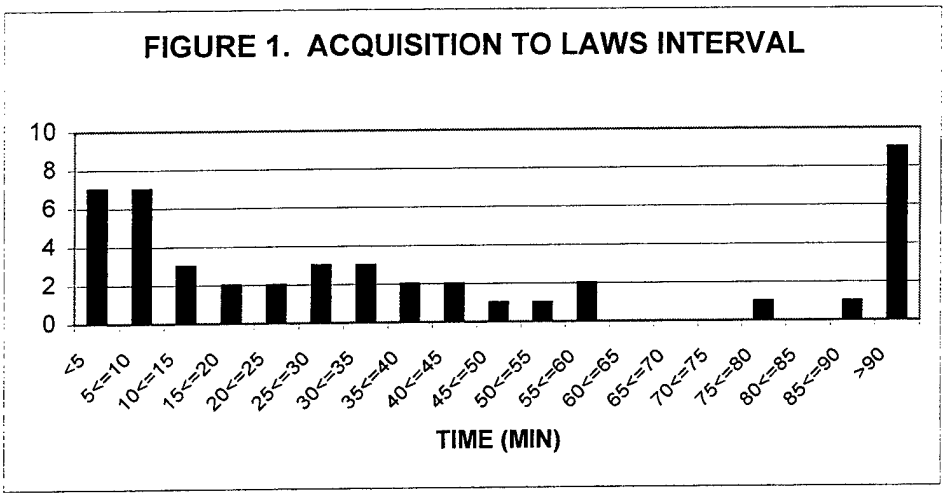
DEN. Target denied for no specified reason.

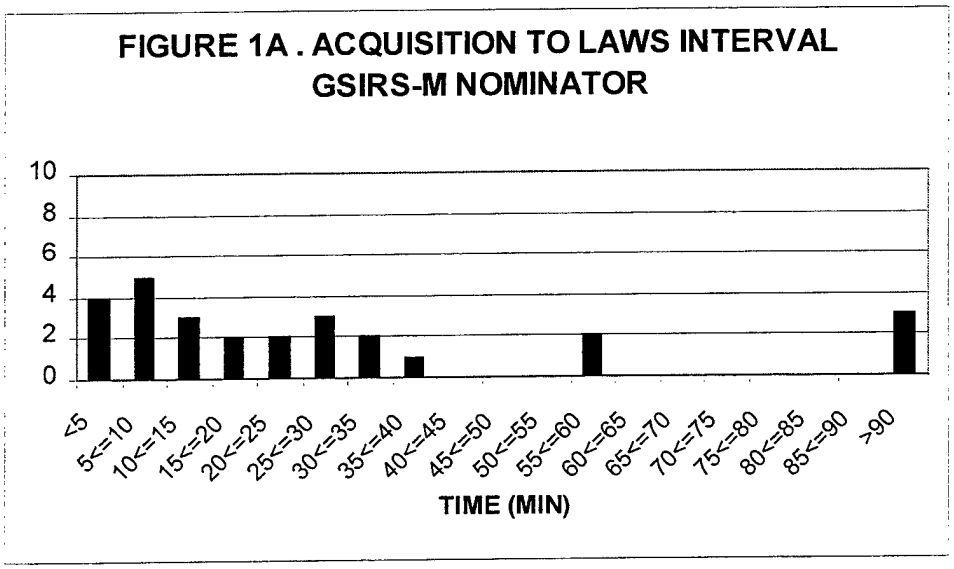
SPD. Remarks in the Targeting Information window report a high speed for the target

INT= Intelligence. Past intell cutoff date. Remarks indicate this flag is also used to indicate needing additional intel data.

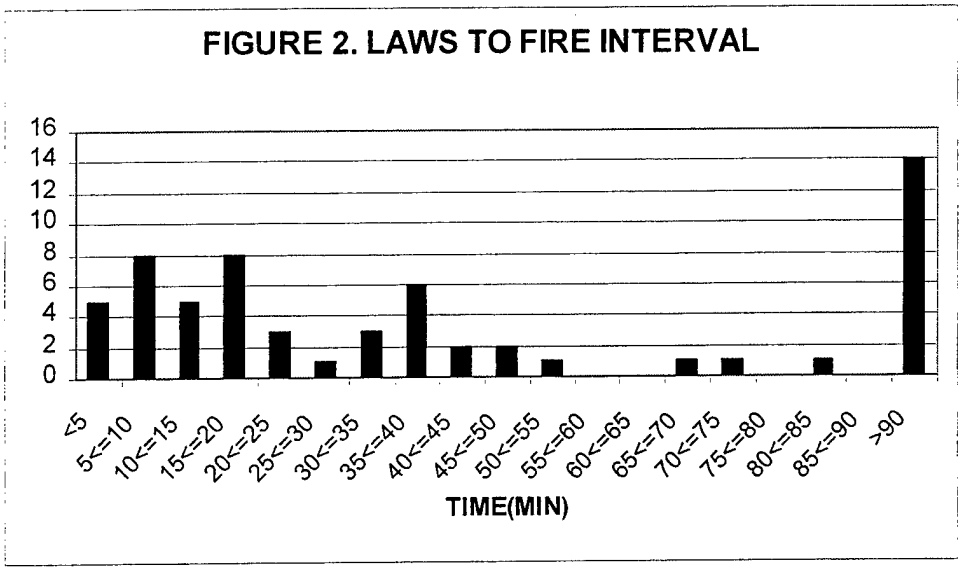
MEN = Need mensuration data.

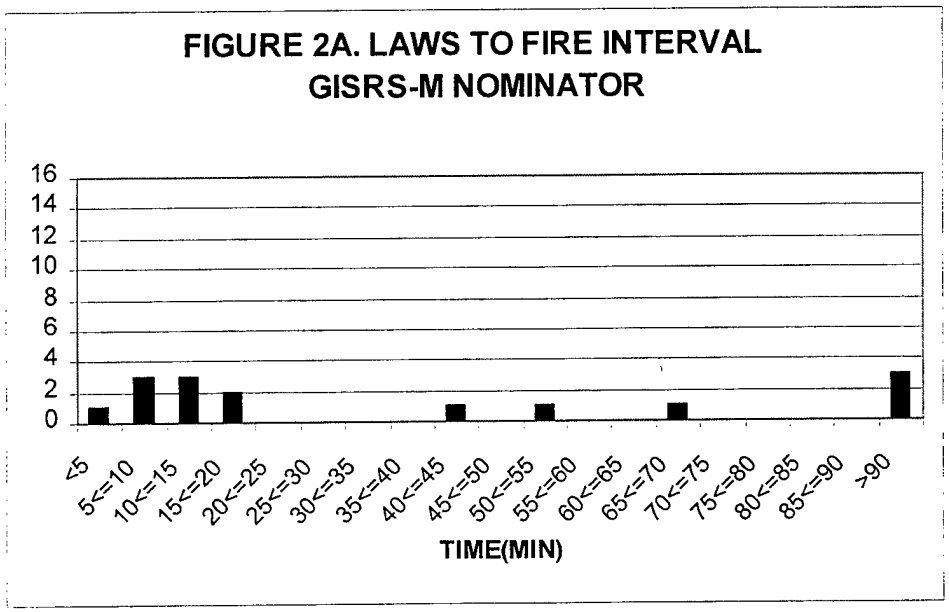
? The reason the target was not fired on was not indicated and is not obvious from the operator remarks.



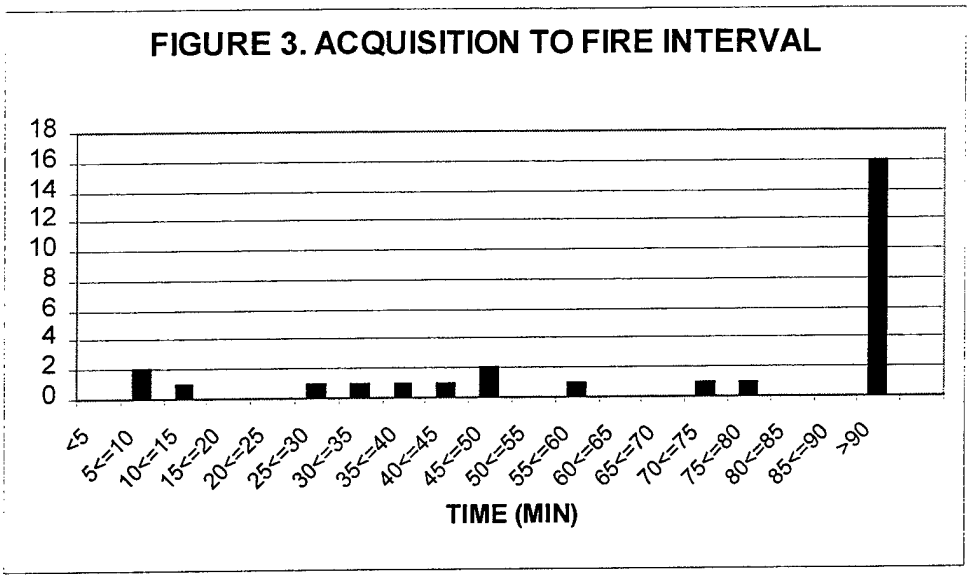


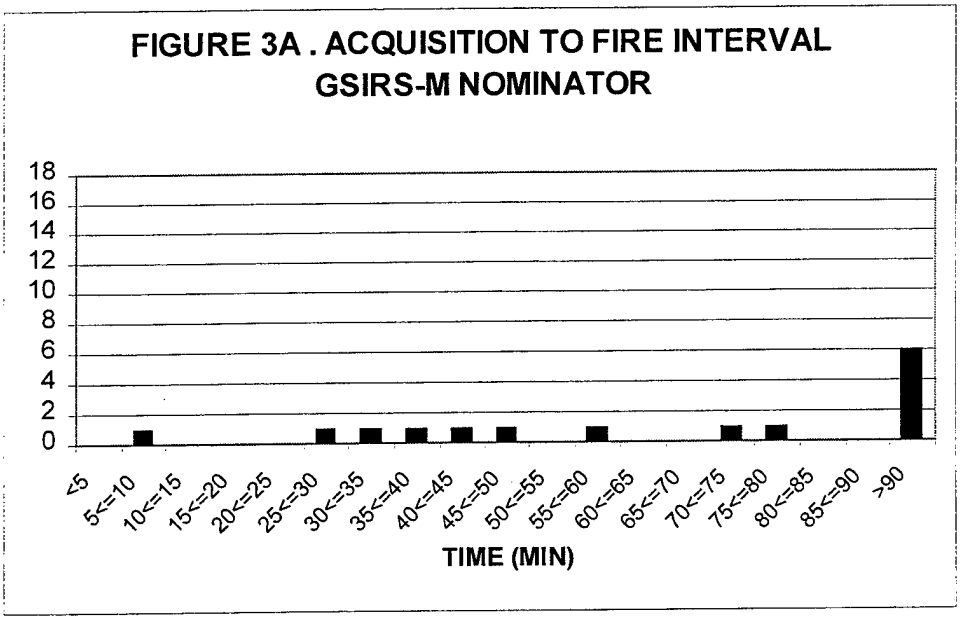
Figures 1 and 1A present the intervals between the sensor acquisition time and the time the target was received at LAWS. Figure 1 includes data for all nominators. Figure 1A includes data only for the GSIRS-M nominator.





Figures 2 and 2A present the intervals between the time the target was received at LAWS and the time the Fired Report event was received at LAWS from the firer. When there was no Fired report Event, the time the fire when ready command was transmitted to the firer was used in place of the Fired Report time. Figure 2 includes data for all nominators. Figure 2 A includes data only for the GSIRS-M nominator.





Figures 3 and 3A present the intervals between the sensor acquisition time and the time the Fired Report event was received at LAWS from the firer. When there was no Fired report Event, the time the fire when ready command was transmitted to the firer was used in place of the Fired Report time. The reported times represent lower limits to the engagement times for TCTs because of these missing Fired Report times and because weapon time of flight is not included. Figure 3 includes data for all nominators. Figure 3A includes data only for the GSIRS-M nominator.

TABLE 4. SENSOR TO ENGAGEMENT THREAD FOR THE GISRS-M NOMINATOR

SENSOR	RPV						ELINT						PI					
WEAPON	TTLAM	MLRS	LASM	ERGM	TACAIR	?	TTLAM	MLRS	LASM	ERGM	TACAIR	?	TTLAM	MLRS	LASM	ERGM	TACAIR	?
TARGET																		
SAM	1	3	1			2			1			1						
CM						1									1			
BM	1	1																
M	1	1										1			1			
AAA																		
PTG	3			1	3													
ATT BOAT																		
SUB					1													
ACFT			1															
RADAR							1								1			
ANTENNA																		
BLDG																		
AMMO DP																		
?																		
TOTALS	6	5	2	1	4	3	1		1			2			3			

SAM = Surface to Air Missile
CM = Cruise Missile position
BM = Ballistic Missile position
M = Missile position
AAA = Air Defense Artillery position
PTG = Patrol Boat, missile
ATT Boat = Fast attack boat
ACFT = aircraft
AMMO DP = Ammo dump
? = unknown

PI = Photo Interpretation

TABLE 5. SENSOR TO ENGAGEMENT THREAD FOR THE PTW NOMINATOR

SENSOR	RPV						ELINT						PI					
WEAPON	TTLAM	MLRS	LASM	ERGM	TACAIR	?	TTLAM	MLRS	LASM	ERGM	TACAIR	?	TTLAM	MLRS	LASM	ERGM	TACAIR	?
TARGET																		
SAM													2		1			
CM																		
BM																		
M														2				
AAA																		
PTG		3										1		1	2			1
ATT BOAT																		
SUB																		
ACFT																		
RADAR														2	1			
ANTENNA																		
BLDG													1					
AMMO DP																		
?																		
TOTALS		3										1	3	5	4			1

SAM = Surface to Air Missile
CM = Cruise Missile position
BM = Ballistic Missile position
M = Missile position
AAA = Air Defense Artillery position
PTG = Patrol Boat, missile
ATT Boat = Fast attack boat
ACFT = aircraft
AMMO DP = Ammo dump
? = unknown

PI = Photo Interpretation

TABLE 6. SENSOR TO ENGAGEMENT THREAD FOR THE JSWS NOMINATOR

SENSOR	SLAR					
WEAPON	TTLAM	MLRS	LASM	ERGM	TACAIR	?
TARGET						
SAM		3				
CM						
BM						
M			1			
AAA				1		
PTG						
ATT BOAT						
SUB						
ACFT		1				
RADAR		1				
ANTENNA						
BLDG						
AMMO DP						
?						
TOTALS		5	1	1		

SAM = Surface to Air Missile
CM = Cruise Missile position
BM = Ballistic Missile position
M = Missile position
AAA = Air Defense Artillery position
PTG = Patrol Boat, missile
ATT Boat = Fast attack boat
ACFT = Aircraft
AMMO DP = Ammo dump
SLAR = Side Looking Airborne Radar
? = unknown

TABLE 7. SENSOR TO ENGAGEMENT THREAD FOR THE JSOTF NOMINATOR

SENSOR	SEAL SR						SOF TM					
WEAPON	TTLAM	MLRS	LASM	ERGM	TACAIR	?	TTLAM	MLRS	LASM	ERGM	TACAIR	?
TARGET												
SAM	1				1							
CM			1								3	
BM												
M												
AAA			1				1					
PTG												
ATT BOAT												
SUB												
ACFT												
RADAR												
ANTENNA												
BLDG												
AMMO DP												
?												
TOTALS	1		2		1		1				3	

SAM = Surface to Air Missile
CM = Cruise Missile position
BM = Ballistic Missile position
M = Missile position
AAA = Air Defense Artillery position
PTG = Patrol Boat, missile
ATT Boat = Fast attack boat
ACFT=Aircraft
AMMO DP = Ammo dump
? = unknown

TABLE 8. SENSOR TO ENGAGEMENT THREAD FOR THE LAWS NOMINATORS

SENSOR:	UNKNOWN					
WEAPON	TTLAM	MLRS	LASM	ERGM	TACAIR	?
TARGET						
SAM		3		2		
CM				2		
BM						
M		4				1
AAA						
PTG						
ATT BOAT			1	1		
SUB						
ACFT				1		
RADAR		7				
ANTENNA		2				
BLDG		2		1		1
AMMO DP		1				1
?			1	2		
TOTALS		19	2	9		3

LAWS nominators include:C5F LAWS, JFK LAWS, JYG LAWS and DOCC LAWS.

In almost all cases the acquiring sensor was not specified.

SAM = Surface to Air Missile
CM = Cruise Missile position
BM = Ballistic Missile position
M = Missile position
AAA = Air Defense Artillery position
PTG = Patrol Boat, missile
ATT Boat = Fast attack boat
ACFT = Aircraft
AMMO DP = Ammo dump
? = Unknown

ANALYSIS OF OBJECTIVE DATA FBE G

Fleet Battle Experiment Golf Time Critical Targeting Process Information from the Land Attack Weapon System

1. INTRODUCTION

The Land Attack Weapon System (LAWS) is one component in the detect-to-engage system used for Fleet Battle Experiment Golf (FBE-G). Its basic purpose is to develop weapon-target pairings from a variety of weapon and target information. When performing this function, information is ingested, processed, and disseminated and displayed, some of which is archived. It is possible to reconstruct Time Critical Targeting (TCT) information from the LAWS data. The purpose of this report is to present such information.

There are limitations to using LAWS for analysis. First, LAWS does not contain all relevant TCT processing information. It is only one component in a larger system. During Golf, the LAWS display was disseminated to many operations nodes and used somewhat as a common operations picture (COP). Thus, the information in it is extensive, but still not complete. Second, not all information developed in LAWS is archived.

Because of these limitations, one cannot expect to do a complete TCT analysis using LAWS data. Even so, such an analysis is valuable. We present here the results from this analysis, including such information as weapon use, percentage of targets engaged, percentage of targets engaged within the TCT dwell time, etc. These results must be interpreted carefully. For example, if the results show engagement times longer than the TCT dwell time, that is a fact. However, since not all events are recorded, the percentage of times this occurred is an indication of overall performance, not absolute statistics.

One of the lessons learned from both Foxtrot and Golf is that a great deal more data should be archived from all of the systems that make up the Fires system, including the communications links. It is important to point out that the purpose of LAWS in these experiments has been to provide a weapon-target pairing process for the operator, not to provide data for the analyst. Thus, the lack of complete data should not be construed as a defect in the system. If the requirement for more complete data archiving is established, the system can be configured to meet that requirement. In order to achieve a complete analysis, this archiving requirement would have to be placed on the several systems that make up the Fires system including the supporting simulations.

2. FIRES SYSTEM

2.1. The TCT Process in FBE G

2.1.1. Sensor Cueing

The sensors applied to the identification of TCTs were the two UAVs organic to each of the two CGs and the Global Hawk and Predator controlled from the IKE/JFACC. These sensors were cued to the areas to search through JSOF, JSWS, Gale-Lite or the Computer Aided TEL Search (CATS).

2.1.2. Target Nomination

UAV simulated imagery and telemetry were fed to the GCCS Intelligence Surveillance and Reconnaissance Capability (GISRC) workstation on the engagement node owning the sensor. There is anecdotal evidence that there were significant delays in the receipt of some of these images at GISRC. There were also some initial problems getting the right image and matching telemetry data sent to the correct platform. The original experiment concept was for the GISRC to feed the same nomination to each of the shooter nodes (Anzio, CSG, CTF67, CTF69, VSSN, JFACC, IKE) with each node assigned a different target number for a given nomination. Due to software problems, this procedure did not work correctly and was not consistently employed in FBE G. The procedures actually used for distributing target nominations were:

a. Multiple nominations from GISRC. Software problems made this approach unreliable.
b. Nomination from GISRC manually delivered to LAWS. The LAWS then distributed the nomination, by ATI.ATR to each of the other LAWS shooter nodes.
c. Nomination from GISRC (ATI.ATR) sent to LAWS. LAWS then distributed the nomination to all of the other LAWS shooter nodes.

The problem of getting the nominations to all shooter nodes continued throughout the test. For the test as a whole, 31% of all target nominations were sent to only a single LAWS shooter node. Even on the last day of experimentation 23 % of the nominations were received by only a single shooter node. Many nominations, though sent to more than one shooter node, were still not sent to all the shooter nodes; this was particularly a problem in the first few days of the experiment.

A protocol evolved to allow participants to refer to the common nominated target even though each shooter platform was given a different target number for the target. For example, a single nomination was sent to each of the shooter nodes with target numbers GA 2053 through GA 2059 inclusive. Associated with each of these different target number was target was a common target description that identified the target as NODONG- GA2053.

2.1.3. Target Nomination Data Entry.

The target nomination was created either by the GISRC or LAWS operator. In the former case, the data contained in the GISRC ATI.ATR message automatically populated the Targeting Information in the LAWS Viewing Fire Mission window. In the latter case, the Targeting Information was manually entered by the LAWS operator. The LAWS data indicates several problems with data entry.

a. The acquisition time was frequently not entered.
b. When entered, the acquisition time was often after the time the nomination was received at LAWS. Timing problems were attributable to the fact workstation clocks were not synchronized and, it appears, in some cases, that the acquisition time was entered as local time rather than GMT.
c. The Not Later Than (NLT) time often did not appear in the LAWS Targeting Information. This may have resulted from a dwell time not being entered in GISRC.
d. In LAWS, the Circular error (CE) and Linear Error (LE) derived from the mensuration were entered in the remarks cell in the Targeting Information. In a few cases the CE and LE values were reported in feet or meters. In most cases no units were specified. Standard units must be used.
e. In a few cases the NLT year was entered as two digits rather than four. This resulted in the failure of the LAWS C2 clock.

These problems can be dealt with by having the GISRC and LAWS software compel the entry of the required data and training the operators in entering the data in standard units.

2.1.4. Dwell Time

The Time Critical Targeting CONOPS for FBE G states "the threshold for timeliness of response varies from target to target. For threshold purposes TCT are grouped into three sets, each requiring engagement within a specified amount of time after detection. These thresholds have been set, for experimental convenience, at five, thirty and one hundred and twenty minutes, respectively". Annex C. APP 2. TAB J, Time Standards for Mobile Targets gives, for each of the FBE G targets types a pre-fire, post-fire and total dwell time. These intervals are given as a function of experiment day (1-6) with the times decreasing as the experiment progresses. The total dwell times for most systems are in excess (often much in excess) of the maximum threshold interval specified in the TCT CONOPS. The GISRC operator, selects from the table the dwell time appropriate to the target type and day of experiment and enters it into the target nomination. The LAWS program, automatically computes an NLT time based on this dwell time. For LAWS, the "NLT is the time that LAWS receives the mission plus the target dwell time provided in the target message sent to LAWS" (ref. Land Attack Warfare System Fleet Battle Experiment Golf). A more accurate definition would have been to define the NLT time as the acquisition time plus the dwell time. However, In practice, this definition would not have been useful in FBE G since the operators often did not furnish the acquisition time.

The effect of a finite dwell time was simulated for a target by the JECG issuing instructions to the JSAF operators to hide the target after the expiration of the appropriate dwell time.

2.1.5. Mensuration

Simultaneous with the nomination of a target to LAWS, ATI.ATR nomination messages and image snapshots, were sent to a JTW or PTW+ workstation. In practice, because of the nomination software problems, the mensuration workstation did not always receive the nomination concurrently with LAWS. In some cases, the mensuration requests and images were hand carried to the local mensuration workstation. The general guidance was that if you were the target nominator and your associated mensuration work station had the necessary database, the target would be mensurated locally. But in some cases, the mensuration request was sent to all mensuration workstations. Sending of the nomination to all mensuration nodes had the effect of creating bidding for mensuration. In practice, each of the mensuration workstations had a terrain database for only a portion of the playing area so that for any given target only a limited number of workstations were capable of providing the mensurated data. The multiple mensuration requests also sometimes resulted in a target being mensurated more than once. All mensuration work stations had the capability to reach back to the other in-theatre workstations with the necessary databases to perform the mensuration or to reachback to ONI. Because of communication problems, only the PTW+ workstation (JFACC) effectively employed reachback for target mensuration.

When the mensuration was completed, it was sent in an ATI.ATR update to LAWS. In practice, most mensuration data were hand carried to the local LAWS. Ideally, all LAWS would receive these mensuration data, but in practice only one LAWS (and one nomination) received the mensurated data. All other LAWS, and the other targets for a given nomination, had to have the target coordinates updated manually. In all cases, the CE/ LE data were automatically entered in the Targeting Information remarks. Ideally, the LAWS operator who received the mensuration data, would also manually update the mensuration information in each of the other target numbers corresponding to a given nomination. The mensuration data were also sent to the DTF where the data were manually entered. Mensuration data were accessed by users either by reviewing ATI.ATR messages received at LAWS or the DTF.

A significant problem was alerting the LAWS operator when the mensuration data were available. Chat was employed, nevertheless operators would often waste valuable time in looking for mensurated data that was not yet available. Suggestions for improvements in this area include a LAWS color block to be set to green when the mensuration data have been transmitted.

There is evidence that, because of the time required to obtain mensurated data, some missions were fired before the mensurated target position had been received. Certainly, the remarks cell in the LAWS Targeting Information often reports no or very low

accuracy CE/LE values. This was particularly true during the first few days of the experiment.

Statistics collected on the mensuration process in FBE G show that during a typical day for the experiment the four mensuration workstations (JTWs on ANZ, CSG and IKE, PTW+ at the JFACC) did an average of eight mensurations with an average mensuration time of about nine minutes. It would appear mensuration capabilities were not stressed.

Reach back for mensuration data was essentially not employed except by the PTW+ in the JFACC. In only a single case did a JTW successfully employ reach back (CSG, in-theater reach back, processing time 55 minutes). For the PTW+, the average mensuration time for reachback to in-theatre databases was six minutes (six instances) and for reachback to ONI databases was nine minutes (55 instances).

2.1.6. Digital Target Folder (DTF)

When a target was nominated the nomination was sent to the DTF cell where the DTF for the target was manually created by the DTF operators. This was a slow process and impacted the servicing of TCTs when it became a requirement that a target could not be fired on until a DTF had been created for it. As a consequence, other nodes took on the creation of the DTFs themselves. Software is needed to automatically create the DTF from the ATI.ATR message.

The primary value of the DTF was in providing participants with mensurated data and BDA. It was time consuming to access to the DTF and frustrating to the user when he discovered that needed information had not yet been posted.

2.1.7. Rapid Planning Mode (RPM)

When processing a TLAM/TTLAM nomination, LAWS requests the missile route from RPM. The four RPM work stations employed in FBE G (ANZ, CSG, C6F, NUWC VSSN) received a total of 350 route requests (excluding mis-formatted requests) over the duration of the experiment (April 5-11). Each workstation received from 1 to 34 route requests per day with an average of about 13 requests per workstation per day. With average route generation time being 1 min 56 seconds (range 39 secs to 6 min 25 secs), route generating assets were generally not stressed. It is estimated that only on 10 to15 occasions was a workstation compelled to queue route requests.

2.1.8. TGT Action

Each LAWS system evaluated the nomination it received. The process of that evaluation was indicated in the TGT Element Approval block on the LAWS Missions Coordination: Fires display. If, for any of a variety of reasons, it was decided not to engage the target the shooter turned the TGT block red and the reason the mission was denied was inserted into the TGT block using one of the following three letter codes.

TIW	TARGET LOCATION IS IN WATER
NDE	NOT DESIRED EFFECT
NHV	NOT HIGH VALUE. DOES NOT MEET ATTACK GUIDANCE
RUT	REDUNDANT TARGET. TGT ALREADY BEING PROCESSED
ENA	EFFECTS NOT ACHIEVED. WEAPON SYSTEM NOT EFFECTIVE
RNG	TARGET OUT OF RANGE
INT	PAST INTELL CUTOFF DATE
NFA	NO FIRE AREA
RFA	RESTRICTED FIRE AREA
FRD	FRIENDLIES IN AREA
RTE	ROUTE IN CONFLICT
OLD	TARGET OLD. TARGET DWELL TIME EXCEEDED
ACA	AIRSPACE COORD AREA
RTG	RESTRICTED TARGET

If the mission was conditionally approved, but was waiting for additional information, e.g. mensuration data, the TGT block was turned yellow. If the mission was accepted, all required data were available, and the mission was ready to be fired, the TGT block was turned green.

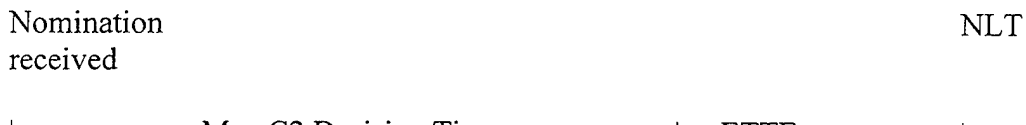
2.1.9. C2 Clock

A new feature of LAWS introduced in FBE G to support the distributed TCT engagement concept was the C2 clock. For a nominated target, LAWS should receive a dwell time with the nomination and with that compute a NLT time for the target (NLT time = the time the nomination was received at LAWS plus the dwell time). Subtracting the Estimated Time to Engage (ETTE) from the NLT time gives what was termed the Maximum C2 Command Decision Time.

The C2 clock was set using the C2 Command Decision Time, which is a sub-interval of the Maximum C2 Command Decision Time. Contained in LAWS was a table that provided a C2 Command Decision Time as a function of the target type and the Maximum C2 Decision Time. When the LAWS operator turned the TGT block green, LAWS then calculated the C2 Decision time and initiated the C2 clock countdown in the Mission Coordination: Fires display. It was incumbent upon the command element to set the CMD approval block to the desired status for a given target number/shooter before the C2 clock reached zero.

Figure 1.

LAWS C2 Clock Timeline



NLT = Time Nomination received at LAWS + dwell time
ETTE = weapon spin up time, time of flight and C2 time both on and off the platform
Max C2 Decision Time interval = NLT - ETTE

In FBE G there were several circumstances that resulted in the C2 clock not operating correctly. They include:

a. No NLT time was entered.
b. No target type was entered or the target type entered was not one of the specific LAWS target types.
c. The operator did not enter a full 4 digit year in the NLT time.
d. If the CMD approval block was initially made red, the clock would not activate if it was changed to another color.

2.1.10. CMD Action: Command by Negation.

Each shooter node independently applied LAWS to the nomination furnished specifically to that shooter. If the target was engageable and all fire constraints had been met (mensuration of necessary accuracy, TLAM route data, etc). The shooter engagement cell would turn the LAWS TGT approval block green. If the CMD approval block was turned green, the shooter was free to fire immediately, if the CMD block was turned red or yellow, he was prohibited from firing. If however, the C2 clock timed out and no CMD action had been taken, the CMD block would automatically turn green and the shooter was free to fire.

It is believed that distributed engagements with command by negation operated more readily early in the experiment. As the experiment progressed, there appeared to be a tendency for centralized control to be exerted. In part, this was the result of the fact the C2 clock often did not work (see 2.1.9), in effect depriving the commander of any opportunity to evaluate his subordinates missions. Consequently, the command blocks would sometimes be immediately turned red for all shooters (this was especially the case on April 10 and 11) and shooters would tend to request permission to fire. This tendency

to centralized control was also manifested by the requirement that a nomination must have a DTF before it could be fired on.

2.1.11. BDA

In FBE G TTLAM missions were transmitted from LAWS through the C4IGW to STOW/JSAF. The simulation flew the missile to the target and performed a casualty assessment. In principle, a sensor would be routed to view the target after the strike to provide BDA. In practice, ship UAVs were generally kept on station from target detection to missile impact. In FBE G, BDA was based on an arbitrary evaluation by the JECG.

For other weapons, TLAM, LASM, ERGM, the fire events were not sent to, and hence not flown out, by JSAF. The assessment of these targets was performed by the manual injection of surrogate weapons by JSAF operators.

The BDA assessment was entered into the DTF folder.

2.2. LAWS Data Flow

In the ATI.ATR nomination message from GISRC, LAWS should receive the following data:

Target number
Target nominator
Target acquisition time
Target acquisition source (e.g. ELINT, UAV)
Target type (must correspond to one of the LAWS defined types)
Target location (e.g. longitude and latitude)
Target altitude
Target dwell time

Other data may be included (e.g. target size, location error) but, in practice, they were usually absent.

When the LAWS operator exercises the Weapon Target Pairing function for a selected mission, LAWS provides a list of Weapon Target Pairing Options. In the context of FBE G, these options include those weapon for the platform associated with a specific LAWS workstation. LAWS does not provide the optimum weapon-target pairing, it is up to the operator to assign a specific weapon from the presented options to fire the mission. The mission is not ready to be fired until the necessary supporting data have been received. These usually include the mensuration data from the JTW/PTW+ workstation which are normally received by LAWS as an updated ATI.ATR message. LAWS automatically enters the CE and LE for the mensurated position into the remarks cell in Targeting Information. In the case of a TTLAM/TLAM mission, the LAWS operator must transmit a route request to RPM. The route data are transmitted back to LAWS from RPM.

When all the data necessary to support a mission have been received, the LAWS operator turns the TGT block green and when CMD clearance to fire is given (or defaulted) the mission is initiated by the LAWS operator executing the fire command.

2.3. LAWS Display

The LAWS displays are discussed from the perspective of post experiment data analysis. The displays described, and the data elements enumerated, constitute the LAWS data used in the TCT data analysis contained in this report.

2.3.1. Mission Coordination: Fires

The key LAWS display is Mission Coordination: Fires. This lists, at all LAWS terminals, all the target nominations distributed to all LAWS nodes. The key information in this display includes:

Target number
Target description
Nominator
Firing unit
Munition

In real time, the display also features the C2 countdown clock, but this is zeroed out in the post experiment display.

The display also exhibits the element approval blocks (TGT, CMD), the fire mission status block (WRD) and the Fired Status block (FRD). When examined post experiment, these blocks exhibit their final state in the experiment.

Most of the details of a mission are accessible from the Mission Coordination: Fires display. Selecting a mission will open the Viewing Fire Mission window which displays Targeting Information which ideally will include the following data:

Target number
Target nominator
Target acquisition time
Target acquisition source
Target type
Target location
Target altitude
Target NLT time
Mensuration CE and LE (in remarks)

The Viewing Fire Mission window also contains Firing Information which normally includes:
Firing unit
Firing unit position

Munition fired
Number of rounds fired in the mission.

For a mission selected in the Mission Coordination: Fires display, selecting the Reports/Mission Times function will display the Mission Timeline Report. This display reports the times of various events during the prosecution of the target. These nominally include:

Nomination received at LAWS.
TGT action
CMD action
Transmission of On Call (OC) fire command
Transmission of fire When Ready (WR) command
Receipt of Fired Report (FRD)

In practice, as described in Section 6, events that should be present are frequently absent and the event time tags are sometimes inconsistent.

2.3.2. Mission Coordination: TLAM

Missions involving either TTLAM, TLAM or LASM munitions should appear in the Mission Coordination: TLAM display as well as the Mission Coordination: Fires display. The information in the former display is similar to the latter with the following exceptions:

VLS cell firing mission
The status of route data
Status block (fired, retargeted, assigned, launch required, ready)

Selecting a mission in the Mission Coordination: TLAM displays the TLAM Mission window which presents additional mission data. These include:

Loiter point Location
Target location
Retargeting target number
Retargeting aimpoint
Time of launch
Estimated Time to Engage (ETE)

In many instances TTLAM missions found in Mission Coordination: Fires do not appear in Mission Coordination: TLAM so that, particularly for loitering TTLAM missions, important mission data are lost. Even when a TTLAM mission appears in both displays, the data in the two displays are sometimes inconsistent (see Section 6). Further, the data in the TLAM mission window are often deficient. For example, the time of launch and ETE are almost never reported and the target location and loiter point location are often the same position.

2.3.3. Mission Coordination: TACAIR

Missions involving TACAIR should appear in the Mission Coordination: TACAIR display as well as the Mission Coordination: Fires display. The information in the former display includes:

Target number
Target description
Mission number
Call sign
NLT time
Mission approval blocks (C6F, JFM, JFC)
Mission status block (FLN)

Selecting a mission in the Mission Coordination: TACAIR display, brings up the Viewing TACAIR Mission window. The most important additional mission data in this displays are:

The number and type of aircraft flying the mission
The number and type of munitions the aircraft will deliver.

Unfortunately, the majority of TACAIR mission do not appear in the Mission Coordination: TACAIR display and when they do, the mission status is usually inconsistent with that displayed in Mission Coordination: Fires (see Section 6).

2.4. LAWS Use as a COP

During the course of the experiment, the operators recognized that LAWS was one of the best sources of battlefield situational awareness they had available and they began to use LAWS as a default COP. We do not report on such use here, but it does illustrate that, regardless of what system is used to provide the COP, it must present much of the information that is present in the LAWS display.

3. TCT PROSECUTION TIME

3.1. LAWS Data and Elapsed Times

The LAWS data used in the analysis of TCT timing include:

Datum	Source
Target acquisition time	Mission Coordination: Fires/ Targeting Information
NLT time	Mission Coordination: Fires/ Targeting Information
Time nomination at LAWS	Mission Coordination: Fires/ Mission Timeline Report
Transmission of OC cmd	Mission Coordination: Fires/ Mission Timeline Report
Transmission of WR cmd	Mission Coordination: Fires/ Mission Timeline Report
Receipt of Fired Report	Mission Coordination: Fires/ Mission Timeline Report

The problems encountered with these data are described in Section 6.

3.2 Results from LAWS

3.2.1. Timeline Data

Timeline analysis in this report is limited to two intervals in the TCT engagement process: the interval between target acquisition time and the time the nomination was received at LAWS (Acq – LAWS interval) and the interval between the receipt of the nomination at LAWS and the fire command/fire event (LAWS – Fire interval).

3.2.1.1. Acq – LAWS Interval

The Acq - LAWS intervals were calculated using the target acquisition time and the time the nomination was received by LAWS as reported in the LAWS Missions Coordination: Fires Viewing Fire Mission window in Targeting Information. In many cases, the acquisition time was not reported (in no case was it reported when a LAWS station or the ANZ or CSG GISRC workstations were the nominators). When acquisition times were reported, in some cases the acquisition occurred after the time the nomination was received at LAWS. The conclusion is that the clocks of several GISRC workstations were incorrectly set. Specifically,

1. For the GS and GI nominators the Acq – LAWS interval is typically about -50 minutes. It is assumed their clocks were off by one hour. Correcting for that, the mean Acq – LAWS interval for these workstations becomes about +9 minutes.

The few values for the GC nominator look plausible with a mean interval of about +14 minutes.

For the GJ nominator, the interval is typically about -6 minutes for April 5-6 and about +10 minutes for April 7-11. This is interpreted to mean the clock was in error for the first few days of the experiment and was corrected on the 7th.

As a consequence, the analysis of the Acq – LAWS interval is based on the values for the GS and GI nominations with one hour added and the values for GC and GJ (limited to post April 6 observations) as they appear in the raw data. For the 36 data points used, the average Acq – LAWS interval was 9.1 minutes and the median interval was 6.5 minutes. This compares with a median time of 23 minutes found in FBE F (see Table 1). The data from FBE F were reformulated to be more comparable to the FBE G data. The median value for the FBE F data was determined by dropping those values where the interval exceeded 90 minutes. Many of these large values are likely to be in error. If these values are included, the median for the FBE F data climbs to 31 minutes increasing the disparity with the FBE G data.

The short Acq – LAWS interval in FBE G is at least partially attributable to the collocation of GISRC and LAWS in each of the shooter engagement cells. It is important

to note that the nomination was generally not actionable upon receipt at LAWS since the target would not yet have been mensurated.

TABLE 1

COMPARISON OF FBE F AND FBE G ACQ – LAWS INTERVALS

EXPERIMENT		# OBS	AVG	MEDIAN
FBE G		36	9.1	6.5
FBE F		30	27.3	23
AVG and Median are in minutes				

3.2.1.2. LAWS – Fire Interval

The LAWS data do not report a time of fire. To approximate the interval from receipt of the nomination at LAWS until fire, we are compelled to use other fire-related events reported by LAWS. The LAWS Mission Timeline Reports may report the following fire–related events: the transmission of the fire On Call (OC) command, the transmission of the fire When Ready (WR) command and the Fired Report (FRD). Unfortunately, these events are not consistently reported, some engagement timelines reported all three of these events, some none, while most reported one or two. In cases where more than one event was reported it was sometimes obvious that one of the event times was in error. For example, where an OC command event and a Fired Report were reported the OC event time tag could be several hours after the time of the Fired Report. Where data appeared to be obviously in error they were excluded from this analysis. However, it is highly probable that erroneous data, particularly some of those exhibiting very large intervals, remain in the sample. For this reason, the analysis was repeated excluding all intervals of greater than 90 minutes. Table 2 presents the FBE G data compared with reformatted data from the FBE G analysis. The first portion of the table shows the results where the LAWS – Fire intervals greater than 90 minutes have been excluded. Comparing the FBE F and FBE G data for the LAWS – Fired Report (FRD) intervals the results are very similar. But comparing the values for the LAWS - WR intervals for the two experiments, the data surprisingly show shorter intervals in FBE F. In FBE F, mensuration was a bottleneck. In FBE G, three JTW and one PTW+ workstation appeared to successfully distribute the mensuration effort resulting in an average mensuration time of 8.9 minutes. Why this did not result in a reduction in the LAWS – WR interval in FBE G is not clear.

TABLE 2

COMPARISON OF FBE F AND FBE G LAWS-FIRE INTERVALS

EXLUDES ALL OBSERVATION WITH INTERVAL > 90				
EXPERIMENT	"FIRE" EVENT	# OBS	AVG	MEDIAN
FBE G	OC	90	19.5	14.5
	WR	30	27	26
	FRD	52	41.1	37
FBE F	WR	40	21.2	16
	FRD	16	38.8	39
	ALL OBSERVATIONS INCLUDED			
FBE G	OC	105	41.1	19
	WR	34	34	30.5
	FRD	80	93.5	67
FBE F	WR	44	37.1	18
	FRD	24	173	63
The Fire events are : OC - issuance of On Call fire command				
	WR - issuance of When ready fire command			
	FRD - receipt of fired report.			
OC events were not reported in FBE F.				
AVG and Median are in minutes				

3.2.1.3. Acquire to Fire Times.

Table 3 presents the total median intervals between acquisition and the WR and Fired Report events excluding observation with intervals of greater than 90 minutes. These times show an improvement in FBE G with respect to FBE F which is entirely due to shorter acquisition to nomination times.

TABLE 3

MEDIAN ACQUISTION TO FIRE TIMES

EXPERIMENT	ACQ-WR	ACQ-FRD
FBE F	39	62
FBE G	32.5	43.5

Times are in minutes

3.2.2. Dwell Times

Dwell time is the intelligence determined theoretical interval of time available to strike a target measured from the time it arrives at a position until it again moves or hides. A critical measure of the success of an engagement is whether a target was hit before the expiration of its dwell time. Because of the importance of this parameter, we use it here to segment the data. In FBE G, the dwell time of a target was determined, by participants, from predefined tables where it was specified as a function of target type and day of experiment. The dwell time was normally inserted in the nomination data by the GISRC operator. We extracted the dwell time values from the LAWS data as described below.

LAWS defined the Not Later Than (NLT) time as:

NLT = Time nomination received at LAWS + Dwell Time.

This definition gives an unrealistically late NLT. A better definition would determine NLT with respect to the target acquisition time. We recovered the dwell time from the LAWS data by subtracting the time the nomination was received at LAWS from the NLT time reported in LAWS.

3.2.2.1. Fired Engagements that Satisfied the NLT

Table 4 presents, as a function of dwell time, the number of fired engagements that
- satisfied the target NLT time,
- possibly satisfied the NLT time, and
- did not satisfy the NLT time.

To be included in this table, an engagement had to have a NLT time reported in LAWS and the LAWS timeline had to report one of the events that approximated the weapon fire time. In order of preference, they are:
- Fired Report event (FRD),
- LAWS transmission of the fire When Ready (WR) command,
- LAWS transmission of the fire On Call (OC) command.

In the majority of cases, only the WR or OC events were available to define the fire time, and these events could occur a number of minutes before the actual fire event. In

addition, the projectile times of flight (TOF) were not directly available. As a result of these uncertainties, in some cases it was not possible to unambiguously determine if an engagement did or did not meet the NLT time constraint. In Table 4, the following relationships are used to define whether the NLT time was met.

The NLT time was satisfied (NLT met) if:

NLT – (the event defining fire time) >= 30 minutes for TTLAM/TLAM
>= 10 minutes for other weapons.

It was uncertain if the NLT time was satisfied (NLT met?) if:

NLT – (the event defining fire time) >0 and <= 30 minutes for TTLAM/TLAM
>0 and <=10 minutes for other weapons.

The NLT time was not satisfied (NLT not met) if:

NLT – (the event defining fire time) <=0.

The LAWS data include firer and target position data. Therefore, using munition TOF tables, the TOF time for the projectile for the engagements could be determined. Calculating the projectile TOF would likely have the effect of moving some of the uncertain cases into the NLT not met column. However, there is no way to deal with the uncertainty in the interval between the OC or WR events and the actual time of fire so the indeterminacy would presumably remain for many engagements. We have not added TOF to the total engagement time.

The last column of Table 4 includes data for targets that were not engaged but which had a reported NLT time.

TABLE 4
ENGAGEMENT NLT STATUS AS A FUNCTION OF DWELL TIME

DWELL	NLT met	NLT met?	NLT not met	Not fired	Totals
<5		4	15	15	34
5<10		1	3	3	7
10<15		2	1	1	4
15<20			2	1	3
20<25				5	5
25<30		1			1
30<60	5	2	10	7	24
60<120	5	1	4	7	17
2<3	15	1	1	10	27
3<4	17	4		9	30
4<10	31	3	3	18	55
10<15					0
15<20	1				1
20<25	4			2	6
>=25				2	2
TOTALS	78	19	39	80	216
Columns:					
DWELL: NLT time - time received at LAWS rounded to nearest minute.					
NLT met: NLT - fire time >= 30 minutes for TTLAM/TLAM, >=10 minutes other weapons.					
Time in minutes to 120, for >= 120 minutes time in hours.					
NLT met ?: NLT - fire time >0 and < 30 minutes for TTLAM/TLAM, <10 minutes other weapons.					
NLT not met: NLT - fire time <=0.					
Not fired. Missions that were not fired					

As Table 4 suggests, engaging targets which have dwell times of less than 30 minutes, within the NLT, is difficult. The ability to do so is a measure of the responsiveness of the Fires system. Thus, we treat such targets as a special case. Table 5 includes details of the 29 fired engagements which had dwell times of less than 30 minutes.

Seven of the eight engagements in which it was uncertain if the NLT time was met occurred in the first two days of the experiment. For those seven engagements, the NLT-Fire Time was four minutes or less. For all of these firings the events available to approximate the fire event were the OC or WR events, and for six of the seven it was the OC fire command, the one most remote from the actual fire event. Considering the unknown intervals between these fire commands and the actual fire event plus the weapon TOF, it appears unlikely that these weapons reached the target prior to the NLT time. Also, as discussed above, the NLT time, as defined by LAWS, is unrealistically late so that the definition of success is biased in favor of the shooter.
This analysis only addresses whether the projectile impacted at the target position earlier

than the computed NLT time, it does not address whether the target was at the position at that time.

TABLE 5
ALL ENGAGEMENTS WITH DWELL <30 MINUTES

Dwell	Weapon	Fire Time Source	CE/LE	NLT - Fire Time	Fired Cmd -LAWS	NLT Eval	Date
12	LASM	OC	100/100	4	8 OC	?	5
12	TTLAM	OC	100/100	3	9 OC	?	5
4	TTLAM	OC	100/100	-45	-1 OC	N	5
4	ERGM	WR	100/100	-2	6 WR	N	5
4	LASM	OC	100/100	2	2 OC	?	6
4	LASM	OC	100/100	2	2 OC	?	6
4	ERGM	WR	100/100	1	3 WR	?	6
6	ERGM	FRD	100/100	-32	38 FRD	N	6
6	LASM	OC		3	3 OC	?	6
4	LASM	OC	100/100	3	1 OC	?	6
3	ERGM	WR	10.8/11.3	-28	31 WR	N	7
4	LASM	OC	9.6/10.1	-36	40 OC	N	7
6	ERGM	WR	11.2/17.2	-24	30 WR	N	7
25	ERGM	WR	10.9/11.4	6	19 WR	?	8
2	ERGM	WR	12.6/18.2	-13	15 WR	N	8
18	ERGM	WR	13.4/18.4	-52	70 WR	N	8
17	LASM	OC	10	-57	74 OC	N	8
3	LASM	OC	11/11	-19	22 OC	N	8
2	ERGM	WR	10/11	-26	28 WR	N	8
5	ERGM	WR	10.8/11.6	-9	14 WR	N	8
2	ERGM	WR	10/10	-9	11 WR	N	8
1	LASM	OC	8/8	-12	13 OC	N	9
1	LASM	FRD	9/10	-36	37FRD	N	9
12	LASM	FRD	8/9	-18	30 FR	N	10
2	LASM	FRD		-35	37 OC	N	10
1	LASM	OC	10/10	-36	37 OC	N	10
2	ERGM	WR	10/11.4	-22	24 WR	N	11
1	LASM	OC	3.1/3	-24	15 OC	N	11
1	TTLAM	FRD	8.5/8.8	-73	74 FRD	N	11

Columns:

Dwell: NLT time - time received at LAWS rounded to nearest minute

Weapon: Weapon fired

Fire Time Source: The LAWS timeline event equated to the fire time: In order of preference FRD=Fired report, WR=Fire When Ready command, OC=Fire On Call command.

CE/LE: Circular Error/Linear Error. Mensuration accuracy reported in LAWS Targeting Information remarks.

NLT- Fire time. The interval between NLT and the event listed in column 3 rounded to the nearest minute.

Fire Cmd - LAWS: The time of the fire command - the time the nomination was received by LAWS. The type fire command used is noted. In order of preference they are WR, OC and FRD.

NLT Eval: NLT evaluation from Table 4. N = NLT not met, ? = uncertain if NLT met.

Date: Experiment day in April from which data came.

3.2.2.2. Mensuration

The CE and LE values from the mensuration process are automatically reported in the LAWS Targeting Information remarks. For almost all engagements in Table 5 for April 5 and 6 the CE/LE values reported are 100/100 implying the targets were not mensurated.

For nine of the ten targets, with dwell times of 12 minutes or less, fired on during the first two days of the experiment, the average interval between the nomination being received at LAWS and a fire command being issued by LAWS was less than four minutes. Given that the average time to mensurate a target using an organic database was 8.9 minutes (this is the time to mensurate at the JTW/PTW+ given receipt of the request, and does not include possible communication delays), it is not surprising that these engagements, with fire commands issued within about four minutes of the receipt of the nomination, were fired unmensurated.

For those 18 cases in Table 5 where the LAWS Targeting Information indicates the targets were mensurated, the average time it took to issue a fire command after the nomination was received at LAWS was about 27 minutes (median time 24 minutes). With one possible exception, all these engagements failed to meet the target NLT times.

4. WEAPON USE

4.1. LAWS Data and Weapon Use

The sources of the data used in deriving the nomination and engagement statistics are:

Datum	Source
Nominations	Mission Coordination: Fires
Nominations engaged	Mission Coordination: Fires
	Mission Coordination: TLAM
TTLAM/TLAM retargeting	Mission Coordination: TLAM
CE/LE	Mission Coordination: Fires/Targeting Info
Rounds fired	Mission Coordination: Fires/Firing Info

4.2. LAWS Results

4.2.1. Nomination and Engagement Statistics

Table 6 contains the summary statistics, as a function of experiment day, for the LAWS data collected in FBE G. To be included as a fired engagement, the criterion was that the Fired Status block (FRD) in the Mission Coordination: Fires display had to be green. This fire criterion was not applied to some TTLAM engagements. Details of defining a fired TTLAM mission are presented in Section 4.2.2. The low number of nominations for April 9 is due, at least in part, to the fact that only a half-day of experimentation was scheduled.

TABLE 6

FBE G TCT ENGAGEMENT STATISTICS

Date	# Nominations	# Single Node	# Engaged	# Engagements	ERGM	LASM	TTLAM	TLAM	TAC	SLAM-ER
5-Apr	32	17	16	18	5	1	11		1	
6-Apr	43	8	26	31	8	6	11	3	1	2
7-Apr	45	14	23	31	5	3	10		13	
8-Apr	50	17	31	37	13	2	18		4	
9-Apr	17	6	8	13	1	3	6		3	
10-Apr	47	12	25	30	1	9	10	1	8	1
11-Apr	30	7	19	25	5	4	12	1	2	1
TOTALS	264	81	148	185	38	28	78	5	32	4
%		30.7	56.1		20.5	15.1	42.2	2.7	17.3	2.2
Columns										
Date: Experiment date										
# Nominations: Total number of targets nominated										
# Single Node: Number of nominations sent only to a single shooter node										
# Engaged: Number of nominated targets that were engaged										
# Engagements: Number of firings. Some nominated targets were engaged by more than one shooter										
ERGM - SLAM-ER: Number of engagements for a specific munition type.										
	This is not a round count. In a few TTLAM, many ERGM missions, multiple rounds were fired.									

In FBE G, the intent was for every nomination to be distributed to every shooter node for evaluation. The original plan was for the distribution to be performed automatically by GISRC. Because of software problems, the distribution of the nominations was performed imperfectly by GISRC. As a fall back, many of the nominations were distributed manually from LAWS. As a consequence of these difficulties, in many cases (30.6%) only a single shooter received the target nomination. In many other cases, the nomination went to more than one, but not all, of the shooters. This problem continued throughout the experiment. Even on the last day of the experiment, 23 percent of the nominations were still being sent to only a single node.

Over the duration of the experiment only 56.1% of the nominated targets were engaged. As the day by day data in Table 6 show, this rate remained more or less constant over the duration of the experiment. Non engagement of some of the targets is attributable to an "end of day" phenomenon – the tendency for targets nominated late in the day not to be prosecuted. This is particularly notable for April 5-7. If, as intended, each of the target nominations was distributed to each of the shooter nodes it likely the number of nominations engaged would have increased.

The number of engagements shown in Table 6 is greater than the number of nominations engaged since, in a number of cases, more than one shooter engaged a nominated target.

Table 6 contains a breakdown of the weapons employed in FBE G. Weapons employed in the engagements were as follows:

TTLAM/TLAM 44.9%,
ERGM 20.5%,
TACAIR 17%,
LASM 15.1% and
SLAM-ER 2.2%.

Table 7 contains a more detailed accounting showing the weapons fired as a function of platform. The data in these tables are not round counts. They count an engagement by a specific platform of a specific target nomination as a single engagement regardless of the number of rounds fired. In many ERGM engagements multiple rounds were fired (see Section 4.2.3) and, in a few cases, multiple rounds were also fired in TTLAM engagements. Specific munitions expenditures are not addressed for TACAIR missions since most TACAIR missions failed to appear in the LAWS Mission Coordination: TACAIR mission list where the specific aircraft and munitions employed in an engagement are defined. Table 7 includes a few instances where LAWS reported inappropriate platform-target pairings: CTF67/ERGM, CVW/TTLAM and CVW/SLAM-ER.

The dominance of the CSG (73 total firings) with respect to the Anzio (34 total firings), is due, at least in part, to the greater reliability of the CSG LAWS connectivity.

TABLE 7

FIRE MISSIONS BY PLATFORM, WEAPON AND DATE

APRIL DATE		5	6	7	8	9	10	11	TOTALS	%
ERGM	CSG	1	5	5	9	1	1	3	25	
ERGM	ANZ	4	3	0	4	0	0	1	12	
ERGM	CTF67							1	1	
TOTAL ERGM		5	8	5	13	1	1	5	38	20.5
LASM	CSG	1	6	1	2	3	6	0	19	
LASM	ANZ	0	0	2	0	0	3	4	9	
TOTAL LASM		1	6	3	2	3	9	4	28	15.1
TTLAM	CSG	4	3	5	6	3	2	3	26	
TTLAM	ANZ	0	0	1	5	1	4	2	13	
TTLAM	VSSN	2	5	2	5	2	1	3	20	
TTLAM	CTF69	4	3	2	2	0	3	3	17	
TTLAM	CTF67							1	1	
TTLAM	CVW	1							1	
TOTAL TTLAM		11	11	10	18	6	10	12	78	42.2
TLAM	CSG		1				1	1	3	
TLAM	ANZ								0	
TLAM	VSSN		2						2	
TLAM	CTF69								0	
TOTAL TLAM		0	3	0	0	0	1	1	5	2.7
TACAIR	JFACC	1	0	4	1	0	2	1	9	
TACAIR	IKE	0	0	3	2	1	2	1	9	
TACAIR			1	6	1	2	4	0	14	
TOTAL TACAIR		1	1	13	4	3	8	2	32	17.3
SLAM-ER	CTF67						1	1	2	
SLAM-ER	CVW		2						2	
TOTAL SLAM-ER			2				1	1	4	2.2
TOTAL FIRE MISSIONS		18	31	31	37	13	30	25	185	
In a few cases LAWS reported inappropriate platform-weapon pairings: CTF67/ERGM, CVW/TTLAM, CVW/SLAM-ER.										

4.2.2. Tomahawk Data

Inclusion of a TTLAM/TLAM firing in Tables 6 and 7 required that:

Fired Status block (FRD) in the Mission Coordination: Fires display be green as with the other weapons, or

the status reported in the Mission Coordination: TLAM mission list be Fired or Retargeted (color blue or green).

Occasionally, the data reported in the two tables were not consistent. There were missions with FRD green in Mission Coordination: Fires but status not Fired or Retargeted in Mission Coordination: TLAM. Conversely, there were some cases where the status was Fired or Retargeted in Mission Coordination: TLAM but FRD was not green in Mission Coordination: Fires. If either mission list listed the mission as fired, it was counted as fired.

Interpretation of the TTLAM/TLAM data is further complicated by the fact that many TTLAM/TLAM missions do not appear in the Mission Coordination: TLAM mission list. The Mission Coordination: TLAM list contains data about a LAWS mission that are not otherwise obtainable. These include the munition specification. All the TTLAM/TLAM missions are listed as TTLAM in the Mission Coordination: Fires list, only in the Mission Coordination: TLAM list will the munition be specified as BLK3 TLAM-C where appropriate. The latter mission list also provides the coordinates of the Target, Loiter Point and Retargeting aimpoints.

A TTLAM mission was considered to be fired at a loiter point if the target description in Mission Coordination: Fires referred to a loiter point or if the targeting information from Mission Coordination: TLAM contained a loiter point position. As discussed above, many TTLAM missions did not appear in the latter list so it is possible some TTLAM loiter missions were not recognized. Table 8 displays TTLAM missions (the five missions identified as firing BLK3 TLAM-C were excluded) by type, date and platform. The mission types are defined as follows:

Non Loiter. A mission is considered to be a non-loitering mission if there was no indication in the Mission Coordination: Fires target description that the mission was fired at a loiter point and, if the mission was reported in Mission Coordination: TLAM, no loiter point or retargeting coordinates were reported.

Loiter Unknown. The mission is known to be a loiter point mission, based on the target description, but is does not appear in the Mission Coordination: TLAM list and, as a result, it is not known whether it went to a default target or was retargeted.

Loiter: Target Box. The mission is known to be a loiter mission but in Mission Coordination: TLAM a position was entered only in the target position and the loiter point and retargeting coordinates are empty, or the loiter point and retargeting coordinates were the same as the target position. This is interpreted to mean that the missile impacted at the loiter box coordinates.

Loiter: Default target. The mission is known to be a loiter mission and a target position and a different loiter box position are entered in Mission Coordination: TLAM . This is interpreted to mean the missile impacted at the default target.

Loiter: Retarget. The mission is known to be a loiter mission. Coordinates are entered in the target position, loiter point position, and retargeting in Mission Coordination: TLAM and the positions are different. This is interpreted to mean the missile was retargeted to a TCT.

The LAWS data in Table 8 show that only 27 of the 78 TTLAM missions (35%) were loitering missions and only five of the 27 (19%) were retargeted to higher priority targets. As Table 8 also shows, during the first few days of the experiment, almost no loitering missions were fired. Limiting consideration to the last four days of the experiment (April 8-11), 25 of 46 TTLAM missions (54%) were loitering.

The interpretation of the TTLAM data are clouded by the inconsistencies between Mission Coordination: TLAM and Mission Coordination: Fires and the fact that critical data are lacking for the missions that do not appear in the former list (41% of the TTLAM missions and 30% of the loitering TTLAM missions, do not appear in Mission Coordination: TLAM). Nevertheless, the LAWS data do suggest that a low percentage of the loitering TTLAMs were retargeted to high priority targets.

4.2.2.2. Priority of TTLAM Targets

Table 9 presents the priority of targets engaged by TLAM and non-loitering TTLAM missions. Priority 1 and 2 targets were engaged in 63% of the engagements. For the four cases where a loitering TTLAM was retargeted to a target of known priority, the priority of all targets was priority 1.

TABLE 9
PRIORITY OF TARGET FOR TLAM AND NON LOITERING TTLAM MISSIONS

	EXPERIMENT DAY							
TARGET PRIORITY	5	6	7	8	9	10	11	TOTALS
1		10	8	9		3	1	31
2		1				3		4
3	8	3	2	2	2			17
4	1						3	4
TOTALS	9	14	10	11	2	6	4	56

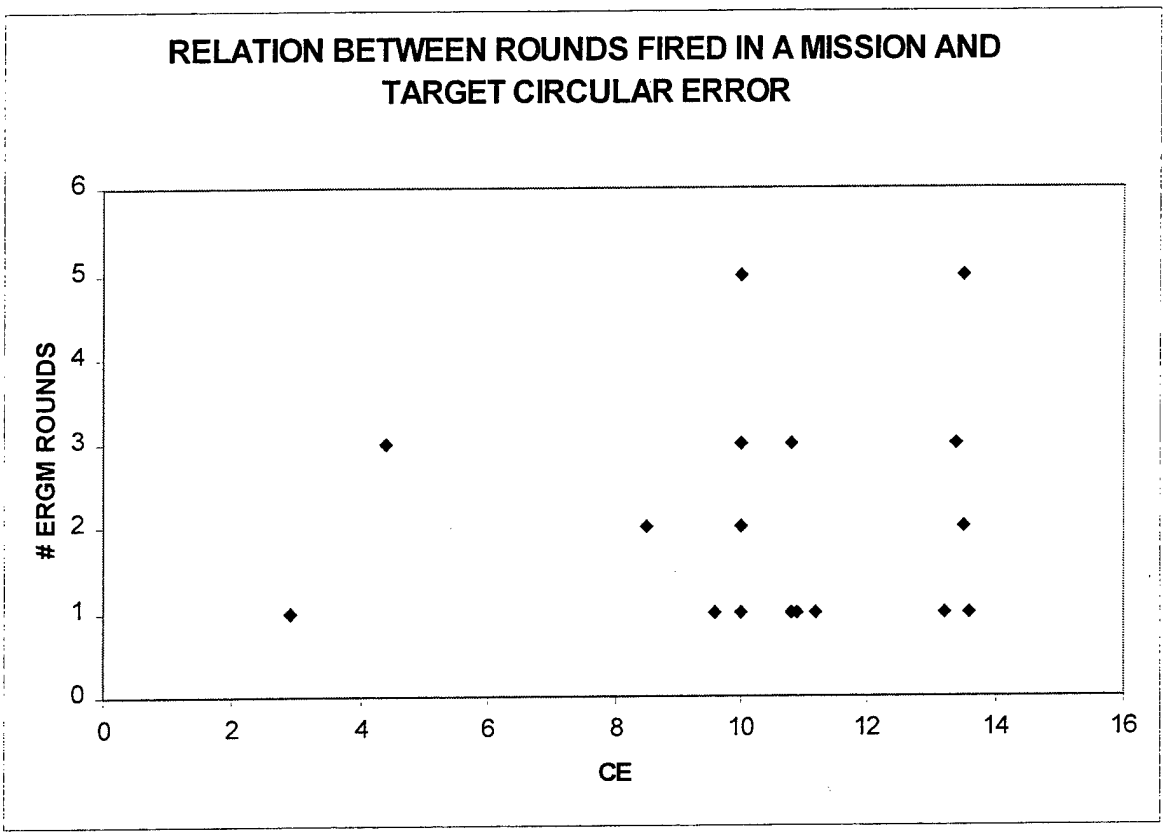
TABLE 8
TTLAM MISSIONS BY TYPE, PLATFORM AND DAY

APRIL DATE	5	6	7	8	9	10	11	TOTALS
CSG NON LOITER	2	3	5	2	1	2		15
CSG LOITER UNKNOWN								0
CSG LOITER TGT BOX				3				3
CSG LOITER: TGT DEFAULT	1				1		3	5
CSG LOITER: RETGT	1			1	1			3
ANZ NON LOITER			1	5				6
ANZ LOITER UNKNOWN					1	4		5
ANZ LOITER TGT BOX								0
ANZ LOITER: TGT DEFAULT							2	2
ANZ LOITER: RETGT								0
VSSN NON LOITER	2	5	2	3	1	1	1	15
VSSN LOITER UNKNOWN				2	1			3
VSSN LOITER TGT BOX								0
VSSN LOITER: TGT DEFAULT							2	2
VSSN LOITER: RETGT								0
CTF69 NON LOITER	4	3	2	1	0	2	1	13
CTF69 LOITER UNKNOWN								0
CTF69 LOITER TGT BOX								0
CTF69 LOITER: TGT DEFAULT							2	2
CTF69 LOITER: RETGT				1		1		2
OTHER TTLAM	1						1	2
TOTAL LOITERING	2	0	0	7	4	5	9	27
TOTAL TTLAM	11	11	10	18	6	10	12	78

4.2.3. ERGM data

Only ERGM engagements frequently used multiple rounds against a given target. A priori, the expectation would be that the number of rounds used in an engagement should be inversely related to the accuracy of the mensurated target position. Figure 2 is a plot of the number of ERGM rounds fired against a target as a function of target CE as reported in LAWS.

FIGURE 2



The points plotted in Figure 2 are limited to experiment days April 7-11 since for most ERGM engagements during the first two days of the experiment LAWS reported no mensuration or poorly mensurated target positions. The above plot indicates no correlation between the number of rounds fired at a target and the accuracy of the CE of the mensurated target position.

4.2.4. Munitions Not Fired

The great majority of the nominations distributed to shooters in the experiment did not result in a firing. It is important to understand why. Some data relating to the mission denial rational is found in the denial codes that appear in the Mission Coordination: Fires

approval blocks. The denial reason are defined in Section 2.1.8. In many cases there was no red approval block, so there is no indication why the mission was not fired. In many other cases, there was a red approval block indicating the mission was denied but it contained no code giving the reason for the denial. Table 10 displays a frequency count for each of the denial codes. The great majority of these codes appeared in the TGT block but a few appeared in the CMD block. Most denials (67% of those reported) are attributable to three reasons: The target NLT time cannot be met, the target is not high value, or the target is out of range.

TABLE 10
REASONS FOR NOT FIRING ON A NOMINATED TARGET

DATE	OLD	NHV	RNG	RUT	RTE	ENA	NDE	FRD	RTG	INT	TIW	RFA	ACA	TOTAL
5	14		3			4	1		1					23
6	15	7	12	4	5	2	2	3	1			1		52
7	9	16	12	8	8	3		1			2			59
8	23	19	24	5	9	3	4		2				1	90
9	9	4	1	2			2		2					20
10	17	10	5	7		4	6	2		4	2			57
11	4	16		3				3						26
TOTAL	91	72	57	29	22	16	15	9	6	4	4	1	1	327

5. PRINCIPAL CONCLUSIONS

This analysis of Time Critical Targets (TCT) in FBE G is based primarily on the logged LAWS data. Over the interval April 5 through April 11, 264 targets were nominated. The principal conclusions of this analysis are as follows.

Only a little over half (56.1%) of the nominated targets were fired on.

For nominations rejected by specific shooters, where the reason for mission denial were reported (327 instances), 67% of the denials were limited to three reasons: The target NLT time could not be met, the target was not high value, or the target was out of range.

The median target acquisition to nomination time was 6.5 minutes. The median nomination to issuance of the fire when ready command interval was 26 minutes. The total acquisition to fire command interval was shorter than that observed in FBE F due entirely to a shorter acquisition to nomination time in FBE G.

For those engagement reporting dwell times (136), 57 % satisfied the target NLT time. The definition of NLT used in the experiment biased this result in favor of the shooter.

With one possible exception, there were no successful engagements of targets with dwell times of less than 30 minutes. These engagements were considered to have failed because the target Not Later Than (NLT) time was not met, the missions were fired unmensurated, or both.

In about 45% of the engagements, the munition employed was TTLAM or TLAM.

Of the 78 TTLAM missions fired, 27 (35%) were loitering mission. Almost all the loitering missions occurred during the interval April 8-11.

The LAWS data indicate that a low percentage of loitering TTLAMs were retargeted to higher priority targets (19%). Incompleteness in the LAWS data make this value a lower limit.

For TLAM and non-loitering TTLAM missions, priority 1 and 2 targets were engaged in 63% of the engagements.

For ERGM missions there appeared to be no correlation between the number of rounds fired and the accuracy with which the target position was mensurated.

Many of the target nominations were not distributed to all of the shooter nodes, about 31% of the nominations were sent to only a single shooter node.

The majority of target nominations with reported dwell times, had dwell times greater than the values of 5, 30, 60 and 120 minutes that FGE G was intended to focus on. 54 % of 216 nominations had dwell times greater than 120 minutes.

6. PROBLEMS WITH THE LAWS DATA IN FBE G

The analysis of the TCT LAWS data was complicated by a number of problems with those data. Some of the problems are attributable to the GISRS and/or LAWS operator data entry and some to LAWS itself. The problems encountered are enumerated below.

1. The target acquisition time was not reported in the LAWS Missions Coordination: Fires Targeting Information for many target nominations. It was reported in none of the nominations identified as originating with LAWS and none of the nominations originating with the Anzio and CSG GISRS.

2. The acquisitions times for some GISRS nominators are often after the times the nominations were received at LAWS. Clocks of all systems need to be synchronized. This acquisition time should be reported in GMT.

3. The LAWS Mission Coordination: Fires Targeting Information frequently did not report an NLT time.

4. The LAWS NLT time was calculated with respect to the time the nomination was received at LAWS rather than the acquisition time.

5. The LAWS Mission Timeline Report was frequently missing events. For example, every fired engagement should have reported a fire When Ready (WR) event and a Fired Report (FRD). Many fired engagements reported only one of these two events and some reported neither.

6. The LAWS Mission Timeline Report frequently reported extraneous events. For example, many engagements, and some non-engagements, reported a fire On Call (OC) event. In Mission Coordination: Fires there is no Fire Mission Status block for On Call commands implying this event should not have been reported in this experiment. Another example of an erroneous event was the occasionally displayed End of Mission event time tagged as 1 Jan.

7. The LAWS Mission Timeline Report sometimes contained erroneous time tags. For example, the OC, WR and FRD events did not always occur in the correct chronological sequence.

8. It would be helpful if certain events could be added to the LAWS Mission Timeline Report including: time on target, time of receipt of mensuration data, time of route request for TTLAM/TLAM missions, time of receipt of route data, and C2 Decision time.

9. TACAIR missions that appeared in the LAWS Mission Coordination: Fires mission list often did not appear in the LAWS Missions Coordination: TACAIR mission list. When they did appear in both lists, the information was often contradictory. For

example, in Mission Coordination: Fires the Fired Status (FRD) block would be green but in Mission Coordination: TACAIR the FLN block would be yellow or white.

10. TTLAM and TLAM missions that appeared in Mission Coordination: Fires would often not appear in Mission Coordination: TLAM. When the missions did appear in both lists, the data were sometimes contradictory. For example, the FRD block in Mission Coordination: Fires would be green but the Status block in Mission Coordination: TLAM could report Launch req. Conversely, there were cases where the Status block in Mission Coordination: TLAM would report Fired but the FRD block in Mission Coordination: Fires would be white.

11. In Mission Coordination: TLAM a loitering TTLAM should exhibit in the Mission Data: a default target position, a loiter box aimpoint and, if applicable, a retargeting aimpoint. In many cases, the default and loitering aimpoints were identical. It appears that the operators were not adequately trained, or constrained by the LAWS software, in setting up loitering TTLAM missions.

12. The LAWS approval and status blocks do not have a protocol for dealing with loitering TTLAMs.

13. LAWS has a data export function that has the potential for being of great help in the analysis and archiving of data. It would be very useful if all LAWS data, in particular all of the Timeline events, were included among the data elements that the export function provides.

14. There are a number of cases where the final color state of the various LAWS blocks do not correspond to a logical pattern. In the examples listed below, the color of the LAWS element approvals, fire mission status and fired status blocks is indicated by the name of the block, an equal sign, and the first letter of the color.

    a. LG 0029 (April 8). CSG TTLAM. TGT=CMD=FRD=G. WRD=R and displays RTG.
    b. GA1037 (April 8) Anzio ERGM firing. TGT=WRD=FRD=G, but CMD=W.
    c. GJ0009 (April 7) Anzio LASM firing. TGT=G, CMD=Y, WRD=W, FRD=G.

15. CE and LE were not consistently reported in the same units. In a few cases, the CE and LE accuracy entered in the remarks were specified in feet or meters. In the great majority of cases, the units were not specified.

16. In a few instances, Mission Coordination: Fires displayed inadmissible weapon target combinations, e.g. CTF67/ERGM, CVW/TTLAM.

17. TGT and CMD missions denials (i.e. red approval blocks) were often not accompanied by a denial code.

ANALYSIS OF OBJECTIVE DATA FBE H

1. Principal Findings.

This section lists the principal findings gleaned from an analysis of the FBE H objective data. The findings are divided into three groups, the groups are:

Operational. Findings related to participant actions.

Experimental Methodology. Findings related to the way the experiment was designed and the way the experimental procedures were defined.

Process. Findings related to the experiment system architecture and its operation.

1.1. Operational Findings.

Sixty-three percent of TST target nominations were engaged. This result is similar to that in FBE F and FBE G.

A plurality of targets were engaged with LASM (46 percent).

The San Jacinto conducted 79 percent of all engagements.

A high percent of missions (including both TST and MTO) called for engagements with multiple rounds (45 percent) but in only three cases were the rounds given individual aim points. Of the eight LASM missions that called for multiple rounds, only three cases fired the required number of rounds.

A large fraction of TST missions (30 percent) were fired unmensurated.

For GISRC the median interval from target acquisition to transmission of the target nomination to LAWS and JTW was 5.1 minutes (mean time was 8.6 minutes).

For JTW the median interval between receipt of the mensuration request and transmission of the mensuration target position was 4.5 minutes (mean time was 7.9 minutes).

For LAWS the median interval between receipt of the target nomination at LAWS until the issuance of the fire when ready command was 14.5 minutes (mean time was 22.6 minutes).

For RPM the median time from receipt of a TLAM or TTLAM route request until transmission of the completed route for a TST target was 80 seconds (mean 79.9seconds).

Few, if any, targets with dwell times of 30 minutes or less were successfully engaged.

BDA data, as manually entered into the DTF, were often inconsistent with the LAWS engagement information.

1.2 Experiment Methodology Findings

The rate of target nomination, determined from the nominations that appear in LAWS, was low (24.8/day including both MTO and TST nominations). But there is evidence that a significant number of nominations did not reach LAWS (see Section 1.2).

Calculated target Not Later Than (NLT) times are often not realistic. NLT times need to be determined based on the knowledge of the state of individual targets.

The San Jacinto engaged 48 percent of its MTO targets. MTO targets were often furnished with no or erroneous and unmensurated target positions. The MTO engagements were fired unmensurated. There was no interaction between the MTO and TST tasking.

1.3 Process Findings

Of those nominations logged as sent by GISRC, 30 percent do not appear in LAWS. Of those nominations logged by JTW, 44 percent do not appear in LAWS. There were five instances where JTW reported a target mensurated but the mensurated data do not appear in LAWS. A mechanism to verify the receipt of nominations and other messages within the DFN is required.

For RPM the median time from receipt of a TLAM or TTLAM route request until transmission of the completed route for MTO missions was median 177.5 seconds with a mean of 321.5 seconds. The corresponding figures for TST targets were 80 and 79.9 seconds. The MTO mission times were much higher because of the near simultaneous request for many TTLAM routes resulting in the queuing of requests, route requests remained in the queue for a maximum of 960 seconds. A single RPM workstation is inadequate for high engagement intensity.

The great majority of weapon firings (at least 77 percent of the engagements) were not sent to, and not fired, flown out, or impacted in JSAF. This had a significant impact on the engagement timeline and utilization of assets due to the delay in target assessment and BDA.

Despite an effort to introduce time synchronization to FBE H there is evidence synchronization was not achieved. This synchronization is necessary to characterize DFN latencies and construct engagement timelines

Latencies in the transmission of: nominations to LAWS and JTW, UAVSim video to GISRC and updates among the LAWS nodes, at times, significantly affected engagement timelines.

DTFs do not log the time and source of each update. The DTFs do not contain target engagement data (e.g. weapon employed, time of fire, time of impact).

2. TST Engagements

In FBE F and G the missions that appeared in the LAWS Mission Coordination: Fires display were limited to TST missions. In FBE H, the LAWS data included some MTO targets in addition to the TST targets. In many cases, a target was identified as an MTO target in the LAWS remarks, in other cases the MTO nature of the target was deduced from the fact it was nominated by the San Jacinto LAWS workstation rather than a GISRC work station. The following discussion refers only to the TST targets unless otherwise stated.

Table1 summarizes the engagement data for TSTs in Phase I of FBE H. The nomination rate in FBE H was low with an average of 19 nominations per day (including the MTO nominations the value goes up to 24.8 nominations per day) compared to 40.6 nominations per day in FBE G. Of the 76 TST targets nominated, 48 (63%) were engaged. The engagement rate in FBE H is similar to that in FBE F (53%) and FBE G (56%).

The nominations examined are those that appear in the LAWS Mission Coordination: Fires display. As will be discussed later (see Sections 5.2 and 7.1), there is evidence that many nominations do not appear in LAWS. A small number of nominations that were described as test cases or inadvertent duplicates have been excluded from the analysis.

The breakdown of weapon types assigned to the TST engagements are listed below:

LASM	45.9%	FASM	2.1%
ERGM	31.3%	TACAIR	2.1%
TTLAM	18.8%		

The choice of weapons shifted dramatically with respect to FBE G. In particular, the TST targets against which TTLAM/TLAM were employed dropped from 44.9 % in FBE G to 18.8 % in FBE H. In FBE G, LASM was employed against 15.1% of the TSTs while in FBE H the corresponding figure is 45.9%. The differences in employment extend beyond these numbers. In FBE G many of the TTLAMs were fired into loiter boxes (35%), in FBE H, however, only TTLAM one targeted to a loiter box. In FBE H, all LASM missions specified a single missile, In FBE H eight of the 21 (38%) LASM TST missions fired called for multiple projectiles.

TABLE 1

FBE H TST ENGAGEMENT DATA

DATE	NOMINATIONS	ENGAGED	ERGM		LASM		TTLAM			TLAM	FASM		TAC	TOTALS
PLATFORM			SAN	DEYO	SAN	DEYO	SAN	DEYO	ALE		SAN	DEYO		
28-Aug	18	12	0	0	9	0	2	1	0	0	0	0	0	
29-Aug	9	4	0	0	1	0	2	0	0	0	0	1	0	
30-Aug	16	7	1	0	2	2	1	0	0	0	0	0	1	
31-Aug	33	25	12	2	8	0	0	2	1	0	0	0	0	
TOTALS	76	48	13	2	20	2	5	3	1	0	0	1	1	48
%		63.2	27.1	4.2	41.7	4.2	10.4	6.3	2.1	0	0	2.1	2.1	100.2
Columns														
Date: Experiment date														
Nominations: Total number of targets nominated														
Engaged: Number of nominated targets that were engaged														
ERGM - FASM: Number of engagements for a specific munition type. This is not a round count, In many missions multiple rounds were fired.														

3. Nominated Targets not Engaged.

For the 28 TST nominations not engaged in FBE H, the LAWS denial codes, or remarks in the LAWS Targeting Information, provided reasons for the target rejection in eight cases (see Table 2). The remarks, in LAWS, indicate the INT rejection code was used in cases where mensuration data were not available. In three other cases, not included in the table, the INT and OLD rejection codes were applied to indicate inadvertent duplicate nominations. A consistent and standardized definition and application of LAWS denial codes is needed.

TABLE 2
REASONS MISSION WERE NOT FIRED AS INDICATED IN LAWS

LAWS CODE	REASON FOR NOT ENGAGING TARGET	# OF CASES
INT	Past Intel cutoff date	3
OLD	Target dwell time exceeded	1
TGM	Target Moving	2
NHV	Not High Value	1
	No hit Area	1

4. Multiple Round Missions.

In many FBE H engagements it was specified in the LAWS Firing Information that more than a single round was to be fired against a target. Table 3 gives the fraction of multiple round missions by weapon type. The data in the table includes both the MTO and TST missions that were fired and appear in the LAWS Mission Coordination: Fires display.

Table 3 includes 48 TST missions and 11 MTO missions. All the multiple round TTLAM/TLAM missions are MTO missions.

TABLE 3
FRACTION OF FIRED MISSIONS CALLING FOR MORE THAN ONE ROUND

WEAPON	#MISSIONS	# WITH >1 RND	%
TTLAM/TLAM	18	3	16.7
LASM	24	8	33.3
ERGM	15	14	93.3
FASM	2	1	50

4.1 Rounds Actually Fired

The LASM data are in particular illustrative of inconsistency in mission execution. Of the eight missions in which more than one round was required, there were only three cases where the requested number of rounds were fired.

In two cases, the requested LASMs were replaced, at least in part, by TTLAMs. For target number GM5032, three LASMs were specified but one LASM and one TTLAM were fired. For target number GM5031 a single LASM round was requested but a single TTLAM round was fired. This latter mission is counted as a TTLAM mission not a LASM mission.

There were also cases (GS0081 and GS0084) where more than the requested number of projectiles were fired. These could be execution errors but, more likely, represent reengagement of targets using the same target number (see Section 4.3).

4.2 Aim Points

For all the cases in which multiple rounds were fired (14 ERGM, 6 LASM, 3 TTLAM/TLAM and 1 FASM), in only three cases were different aim points used for the individual projectiles:

For target number GS0038 (an MTO target), three TTLAMs were fired at the same aimpoint one at a different aimpoint.

For target number GS0040 (an MTO target), all four TTLAMs were fired at different aimpoints.

For the GS0081 TST mission, only one LASM round was requested but 2 TTLAMs and one LASM were fired, two at one aimpoint the third round at a different aimpoint.

4.3 Multiple Rounds Engagements Result in Missing LAWS Data

LAWS permits target reengagement using the same target number, but the LAWS Mission Coordination: Fires timeline reports timeline events for only one of the projectiles. For LASM, TLAM and TTLAM firings the individual launches are listed in the Mission Coordination: TLAM table but the times of the individual launches are not reported. This may not be a serious problem where multiple rounds are requested and they are fired virtually simultaneously. It is a problem when the mission is refired after a long interval. The Missions Coordination: Fires timeline records data for only one of the firings and data for the other is essentially lost. It is proposed that a unique target number be created for each distinct weapon firing at a target. For example, if a LASM is fired at target number GS4444, which is subsequently engaged with a TTLAM, the TTLAM reengagement appear in Mission Coordination: Fires and Mission Coordination: TLAM as GS4444A.

5. Mensuration.

When mensuration data are received at LAWS, the Circular Error (CE) and Linear Error (LE) values are automatically recorded in the remarks area of the targeting information. In the case of the San Jacinto, the JTW- LAWS communication link was not functioning, therefore, the mensuration data were not transmitted in an ATI.ATR message to LAWS. Consequently, the LAWS operator manually entered mensurated coordinates and the CE/LE data. The absence of CE/LE values in the LAWS Targeting Information is taken as evidence that the target was unmensurated. Unmensurated TST missions include the following:

Of the 22 LASM missions 6 (27.3%) were fired unmensurated.
Of the 15 ERGM mission 5 (33.3%) were fired unmensurated.
Of the 9 TTLAM missions 3 (33.3%) were fired unmensurated.

Firing of TTLAMs at unmensurated targets does not necessarily represent a procedural failure in that the mensurated target position can be transmitted to the in-flight missile. But in FBE H, only one TTLAM was retargeted and it was not one of the unmensurated launches.

The great majority (82 percent) of the unmensurated firings for LASM and ERGM occurred on 31 August.

For two of the unmensurated nominations, the JTW data log sheets (see 5.1) confirm that target mensuration was not performed due to the lack of Digital Point Positioning Database (DPPDB) data.

5.1 JTW Data.

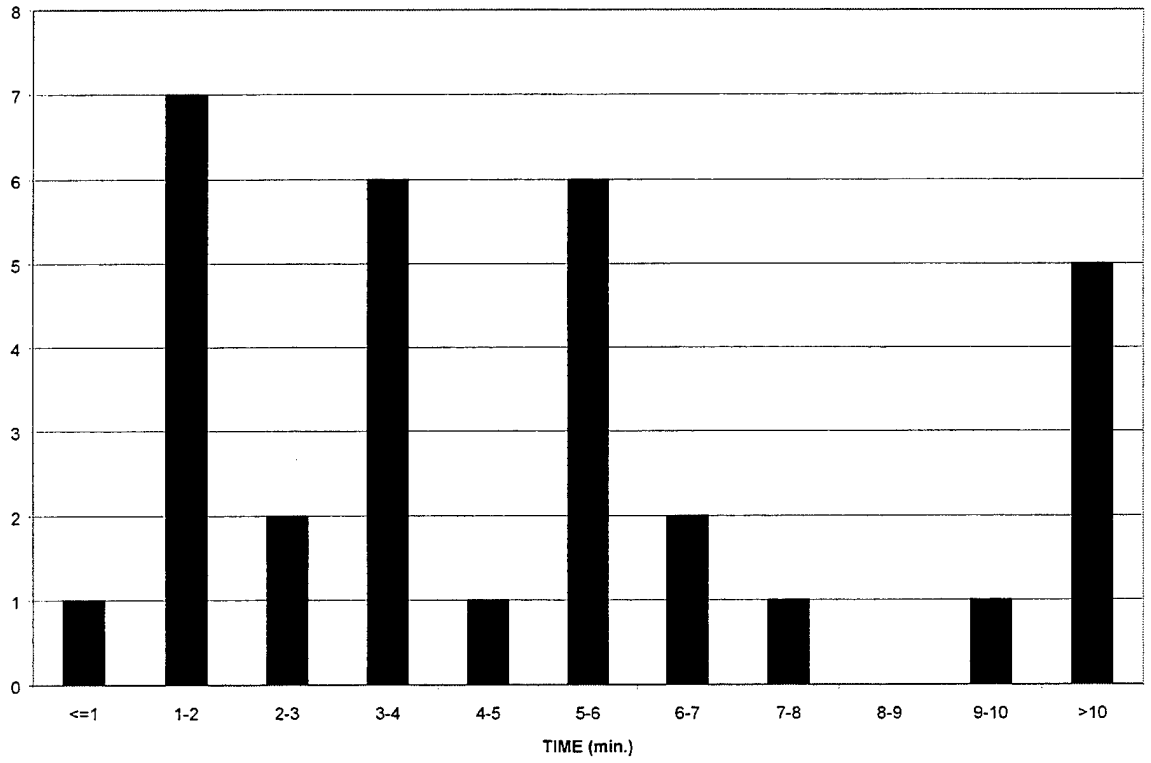
JTW data were successfully collected only on the MTW and HST. Mensuration was performed on 36 (72%) of the 50 nominations received by those two platforms. The JTW data were not automatically logged. The operator manually recorded the time the request was received from GISRC, the time the mensurated data were sent to LAWS and the actual time spent mensurating the target. In most cases where the target could not be mensurated, it was because there were no DPPDB data for the target area (this occurred for 10 nominations). Table 4 contains summary data compiled from JTW data sheets supplied by Bruce Butts (NRO). For the two platforms that supplied mensuration data, the average mensuration time from the receipt of mensuration request until the data were transmitted was 7.9 minutes similar to the average of about nine minutes in FBE G. As Table 4 shows, the average mensuration time for the MTW was 6.3 minutes with zero time in queue. But for the HST, even on days with few requests, there were significant delays in the queue (average mensuration time 3.9 minutes, average receipt to send time 8.4 minutes). The FBE H mensuration time average was somewhat reduced due to fact that on Aug 31 the HST JTW mensurated 10 targets from a single UAV image. The effect of that unusual circumstance on mensuration time is obvious in the August 31 HST data in Table 4.

Figure 1 is a histogram of the intervals measured from the receipt of the mensuration request until the transmission of the mensurated target position.

TABLE 4
JTW DATA

				RECEIPT TO SEND		MENSURATION TIME	
PLATFORM	DATE	#REQUEST	#MENSURATED	AVG	MEDIAN	AVG	MEDIAN
MTW	28	4	2	10.5	10.5	10.5	10.5
MTW	29	3	0				
MTW	30	0	0				
MTW	31	7	5	4.6	4	4.6	4
MTW	ALL	14	7	6.29	5	6.29	5
HST	28	6	5*	14	14	10	10
HST	29	6	3	33	16	8	7
HST	30	4	3	7	7	5.3	5
HST	31	20	18	3.7	3	2.3	2.5
HST	ALL	36	26	8.4	4	3.9	3
MTW,HST	ALL	50	33	7.9	4.5	4.4	4
*three of the mensurations were interrupted by briefings and are not included in the totals							

FIGURE 1
HISTOGRAM OF JTW RECEIPT OF NOMINATION TO COMPLETION INTERVAL
(33 observations)



5.2 Missing Nominations

A comparison of the 50 target nominations received by the JTWs on the MTW and HST with the target nominations reported in the LAWS Mission Coordination: Fires display shows that 22 (44%) of the JTW nominations did not appear in LAWS. Further, there were five cases where the JTW logs state the target was mensurated but the CE/LE values indicative of a mensurated target were not reported in LAWS implying the updated ATI.ATR message sent from a JTW were not received at LAWS. There is at present no mechanism to verify the receipt of ATI.ATR messages sent between GISRC, LAWS and JTW. Such a mechanism is required. Missing nominations are discussed further in Section 7.

6. Acquisition – LAWS Interval.

GISRC defines the acquisition time as the time that the GISRC operator creates a track (or updates an existing track) of a militarily significant object. GISRC automatically records and logs this event. This acquisition time is included in the ATI.ATR nomination to LAWS and is reported in the LAWS Targeting Information. In FBE H, changes to the GISRC software ensured the inclusion of the acquisition time in the ATI.ATR message, an improvement from FBE G.

Despite the attempted introduction of time synchronization for all systems for FBE H, timing problems persist. With regard to the interval between Acquisition and receipt of the nomination at LAWS (hereafter LAWS-ACQ) these timing problems were manifested in two ways:

1. For most of Phase I of FBE H (Aug 28-31), the LAWS-ACQ interval for the GM and GC nominators (GISRC MTW and Cherry Point) averages about four minutes which is consistent with time estimates of GISRC operators. The LAWS-ACQ interval for the GS and GH nominators (GISRC San Jacinto and HST) averages about one hour and four minutes. It is possible that the LAWS workstations on the HST and the San Jacinto were reset to local time for a more easterly time zone.

2. For the last part of the day on Aug 31 the LAWS-ACQ interval for several GH nominations was about 58 minutes (given the above assumption, this implies the LAWS-ACQ interval is negative for these engagements) and the interval for one nomination from GC was -9 minutes. This suggests LAWS and GISRC were out of synchronization by roughly 10 minutes.

Accordingly, in determining the values for the ACQ-LAWS interval 60 minutes was subtracted from the values for GS and GH nominations and data subsequent to the GH0225 nomination on August 31 were discarded.

For 60 TST nominations (excluding data subsequent to nomination GH0225 on Aug 31 and two outliers where the interval was greater than one hour) the mean time between acquisition and receipt of the nomination at LAWS was 5.15 minutes with a median time

of four minutes. In the LAWS data, the acquire time is reported in minutes, time of receipt at LAWS is reported to the second but that time has been rounded to the nearest minute. Table 5 below compares the data from the last three FBEs.

TABLE 5

ACQUISITION TO RECEIPT OF NOMINATION AT LAWS INTERVALS
(times in minutes)

EXPERIMENT	#OBSERVATIONS	AVG.	MEDIAN
FBE H	60	5.7	4
FBE G	36	9.1	6.5
FBE F	30	27.3	23

Even though the total number of nominations in FBE H was much smaller than in FBE G, the sample size presented in the table is larger because of the changes made to GISRC to ensure acquire time was recorded for every GISRC initiated nomination.

As will be discussed in Section 7, the event data from GISRC, available for the first time in this experiment, provided evidence that the ACQ- LAWS interval determined as above, is subject to a timing error. Nevertheless, the calculation was performed to provide a direct comparison with the data from previous experiments.

7. GISRC Data

Each GISRC workstation (San Jacinto, MTW, HST and Cherry Point) logged information for each target acquired and nominated. The GISRC data were supplied by Jim Burdell and Greg Bulla (SPAWAR). The GISRC data are not complete, particularly early in the experiment when the data logging program was being modified. The logged GISRC data contain 37 instances where nominations were sent to LAWS compared to the 76 TST nominations that LAWS actually received.

For this analysis, the first TOT time (= acquisition time), nomination time and the time nomination was sent were used to compute the interval between acquisition and nomination (ACQ-NOM), the interval between nomination and the time the nomination was sent to LAWS (NOM – SEND) and the total interval between acquisition and sending the nomination (ACQ – SEND). As Table 6 indicates, the GISRC processing time is predominately involved with the mechanics of preparing the nomination message and selecting and appending imagery to it (i.e. the NOM-SEND interval). Because the data contain outliers the median values are considered more representative.

TABLE 6
GISRC TIME INTERVALS
(times in seconds)

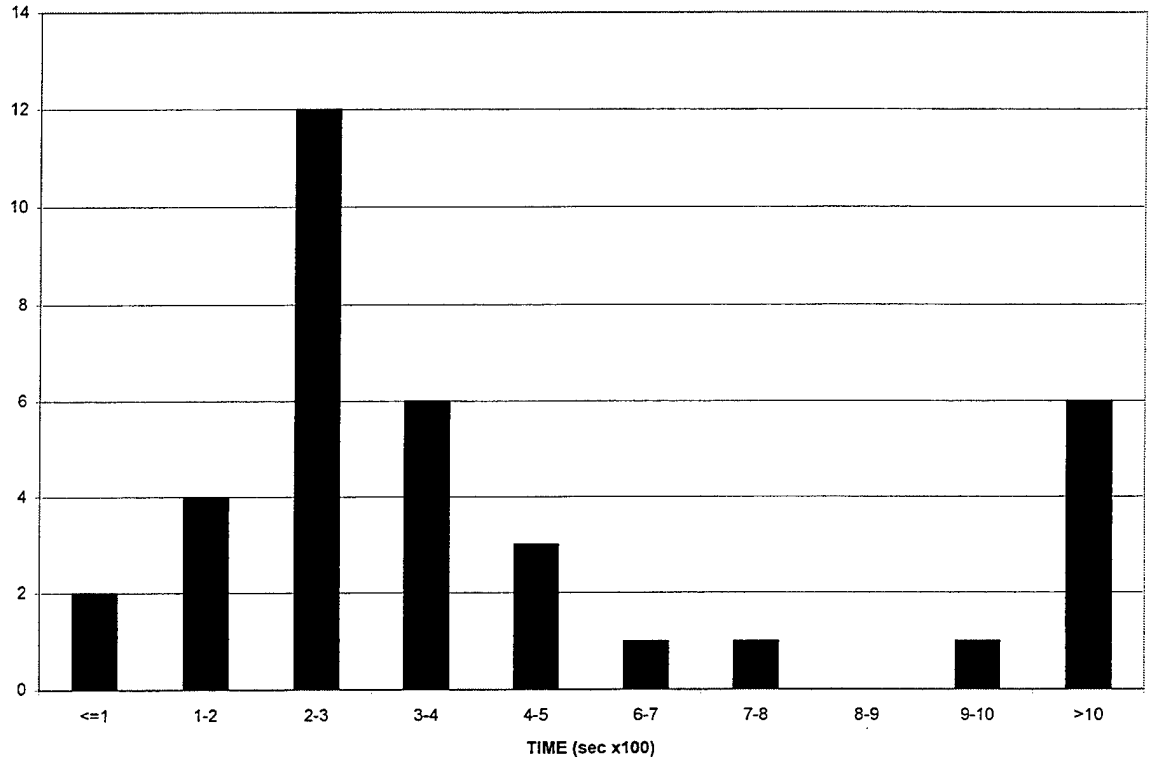
	ACQ-NOM	NOM-SEND	ACQ-SEND
# OBSERVATIONS	41	35	36
MEAN	162.98	384.14	515.56
MEDIAN	10	248	305.5

The GISRC median ACQ-SEND interval of five minutes (305.5 secs) should be compared to the value reported in Table 5 which shows the median interval between GISRC acquisition and receipt of the nomination at LAWS was four minutes. The two populations of nominations used to determine these medians are not identical so the values are not directly comparable, but it would be expected that if anything, the latter interval would be longer. Construction of time lines for several engagements showed cases for which the time that GISRC reported the nomination was sent to LAWS was about 50 seconds after the time that LAWS reported the nomination was received (one of these timelines in shown in Table 11). This appears to be another manifestation of unsynchronized clocks on different systems.

Figure 2 presents a histogram of the ACQ-SEND interval for 36 GISRC nominations.

Of the 37 cases where GISRC logged a nomination sent time (one reported an erroneous time and is not included in Table 6 or Figure 2), 11 were apparently not received by LAWS in that they do not appear in the LAWS Mission Coordination: Fires list. Again, a mechanism for confirming receipt of, and for re-sending nominations is required.

FIGURE 2
HISTOGRAM OF GISRS ACQUIRE TO TRANSMIT NOMINATION INTERVAL
(36 Observations)



8. LAWS – Fire Interval.

The LAWS timeline events relating to weapon firing are frequently missing and occasionally obviously erroneous. The transmit On call (XMT OC), and transmit when ready (XMT WR) fire commands and the Fired Report (FRD) randomly appear or are absent for the fired engagements. This was also in the case in FBE F and FBE G. Table 7 provides the statistics on the FBE H fire times in comparison with the data collected in FBE F and FBE G. The data from FBE H are distinguished by the small sample size and the absence of the high value (and probably erroneous) outliers found in the earlier experiments.

TABLE 7

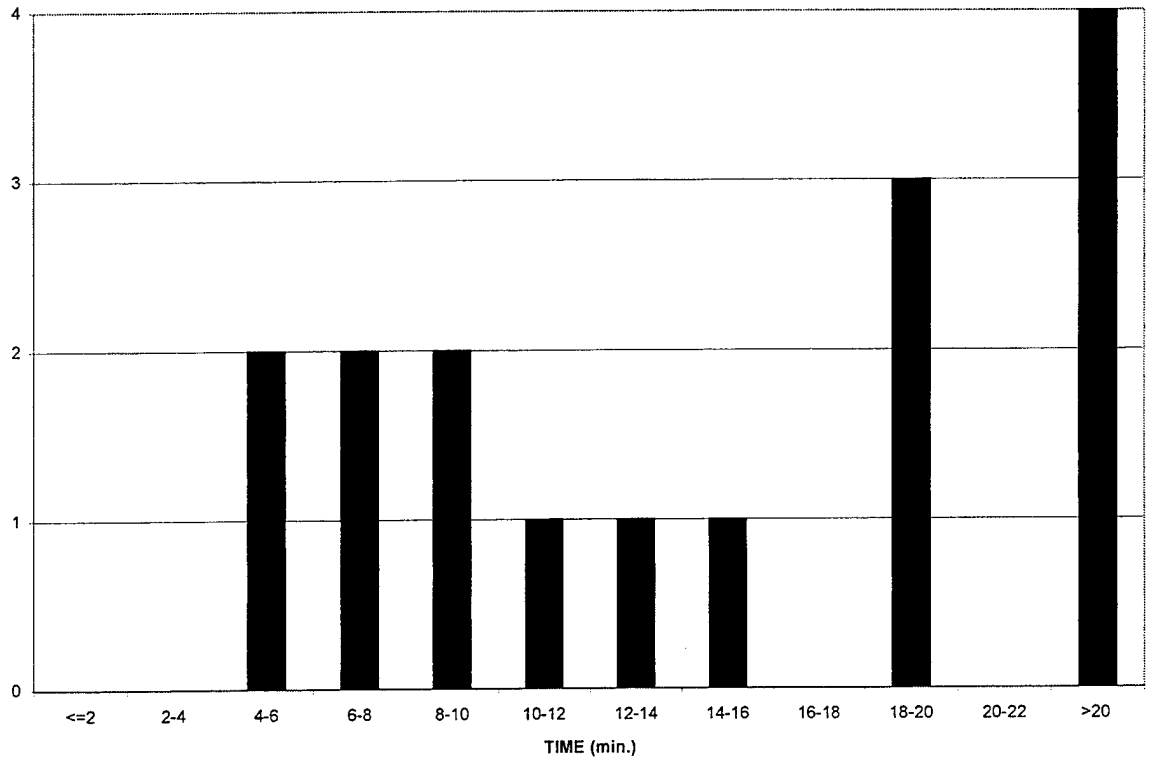
INTERVALS FROM LAWS RECEIPT OF NOMINATION TO FIRE RELATED EVENTS

	EVENT								
	OC			WR			FRD		
EXP	#OBS	AVG	MED	#OBS	AVG	MED	#OBS	AVG	MED
FBE H	10	22.3	20.5	16	22.6	14.5	11	44	48
FBE G	90	19.5	14.5	30	27	26	52	41.1	37
FBE F	NA			40	21.2	16	16	38.8	39

The events in the table are:
OC: Issuance of On Call fire command.
WR: Issuance of When Ready fire command.
FRD: receipt of Fired report.
Average (AVG) and Median (MED) times are in minutes.
The statistics reported for FBE G and FBE F exclude outlying observations where the intervals exceeded 90 minutes. The intervals between the receipt of the nomination at LAWS and the various fire related events shows no substantial change over the three experiments.

Figure 3 is a histogram of the LAWS the intervals between the receipt of the target nomination at LAWS and the issuance of the f ire when ready command.

FIGURE 3
HISTOGRAM OF THE LAWS RECEIPT OF NOMINATION TO THE FIRE COMMAND (WHEN READY) INTERVAL
(16 Observations)



9. Dwell Times.

A table of target dwell times for use in FBE H was created by Jim Burdell (SPAWAR). On nominating a target, the GISRC operator selected a target type and the dwell time for that target type was automatically entered into the LAWS nomination message. LAWS does not report the dwell time, but computes and reports a NLT time that is based on the dwell time. In this analysis, the dwell times were recovered from the reported LAWS NLT times by taking the difference between the NLT time and the time the nomination was received at LAWS. In general, these computed dwell times corresponded with the tabular dwell times, for the appropriate target types, as contained in the dwell time table. However, particularly in the first days of the experiment, it appears some of the GISRC operators were manually inserting erroneous dwell times. In particular, SCUD dwell times were correctly found to be 30 min. for August 30 and 31 but on August 28 and 29 they varied from 9 min. to 2 hrs. For these latter two days the GM nominator reported the correct value, but the GS and GH nominators did not.

10. Definition of NLT Time

As described in Section 9, LAWS calculates the NLT time by adding the dwell time to the time the nomination was received at LAWS. This NLT value is an optimistic estimate from the perspective of the shooter, in the sense that he will be led to believe the target will be engageable longer than it in fact would. Often, a better approximation to the NLT time would be obtained by adding the dwell time to the GISRC reported acquisition time. However, in those cases where the target is observed to stop and the nomination then updated, the current NLT definition is appropriate. The treatment of dwell and NLT times should be reexamined and adapted to reflect the knowledge and status of specific targets.

A separate issue is the play of dwell times in JSAF. JSAF has the capability of automatically moving or hiding a TST after the expiration of its dwell time. It should be ensured that this feature of JSAF is employed so that if projectiles are impacting after the expiration of a target's dwell time and its consequent movement out of the projectile impact area, they are not being credited with a kill.

10.1 Meeting NLT Times

Table 8 displays the engagement NLT status as a function of dwell time. That is, was the target hit within the dwell time (NLT met), was the target not hit within the dwell time (NLT not met) or is the result uncertain (NLT met?). The latter category was applied to TLAM or TTLAM launches for which the interval between the LAWS fire event and the NLT time was less than 30 minutes or ERGM and LASM launches for which that interval was less than 10 minutes. The uncertainty in the actual fire time and the projectile time of flight means it is uncertain whether the projectile would have struck the target before expiration of the dwell time. The LAWS Mission Timeline Report may report three fire related events: transmission of the On Call (OC) fire command, transmission of the When Ready (WR) fire command, and the Fired Report (FRD). Whether these data are present or not for a fired mission is unpredictable. In the case of FBE H, there are many cases where the Mission Coordination: Fires and the Mission Coordination: TLAM displays indicate the missions were fired but the corresponding Mission Timeline Reports contain none of the fire related events. This circumstance is reflected in the "unknown" NLT status. As Table 8 indicates, all those engagements where the NLT time was unequivocally not met were for dwell times of 30 minutes or less. Table 9 contains details of the 11 fired engagements with dwell times 30 minutes or less for which there was some information related to the mission fire time. This table reports the CE/LE accuracy of the mensuration as reported in LAWS. A value of 0/0, 100/100 or a blank indicates that the target was unmensurated. As the table shows, the only two cases (GS0091, GC0067) where the dwell times were 30 minutes or less in which the targets were judged to have been hit within their dwell times, appear to have been fired unmensurated. GC0067 was an ERGM mission and the firing of five ERGMs may represent an attempt to compensate for the absence of mensuration. But all five ERGMs were targeted at the same aim point.

TABLE 8

ENGAGEMENT NLT STATUS AS A FUNCTION OF DWELL TIME

DWELL	NLT met	NLT met?	NLT not met	Unknown	Not fired	Totals
10				1		1
20		1				1
30	2	1	7	5	12	27
60	2			6	2	10
90	13	1		2	4	20
120				3		3
>120	1			1	4	6
TOTALS	18	3	7	18	22	68
Columns:						
DWELL: NLT time - time received at LAWS rounded to nearest minute.						
NLT met: NLT - fire time >= 30 minutes for TTLAM/TLAM, >=10 minutes other weapons.						
	Time in minutes to 120, for >= 120 minutes time in hours.					
NLT met ?: NLT - fire time >0 and < 30 minutes for TTLAM/TLAM, <10 minutes other weapons.						
NLT not met: NLT - fire time <=0.						
Uknown: Mission was fired but the LAWS Timeline Report contains no fire realted events.						
Not fired. Missions that were not fired						

TABLE 9

ALL FIRED ENGAGEMENTS WITH DWELL <= 30 MINUTES AND A LAWS REPORTED FIRE TIME

Dwell	Weapon	Firer	TGT #	Fire Time Source	CE/LE	NLT-Fire Time	Fired Cmd-LAWS	NLT Eval	Date	Remarks
30	TTLAM	DEYO	GM0055	OC	6/5	-13	42	N	28	
30	TTLAM	DEYO	GM5021	OC	0/0*	-14	43	N	28	
20	TTLAM	SAN JAC	GS0059	OC	8.3/8.2	12	7	?	28	
30	TTLAM	SAN JAC	GS0065	OC	14.2/11.9	20	9	?	29	
30	TTLAM	DEYO	GM5031	OC	6.2/5.6	-6	35	N	31	
30	LASM	SAN JAC	GS0084	FRD	18.1/17.1	-19	48	N	31	Fired 2 LASM
30	LASM/TTLAM	SAN JAC	GM5032	OC (FRD)	6.1/5.5	1 (-40)	28 (69)	N	31	Fired 1 LASM, 1 TTLAM
30	ERGM	SAN JAC	GS0085	WR (FRD)		20 (-14)	10 (44)	N	31	
30	ERGM	SAN JAC	GS0086	FRD	18.8/17.0	-1	30	N	31	
30	LASM	SAN JAC	GS0091	FRD		27	3	Y	31	
30	ERGM	DEYO	GC0067	WR	100/100*	16	13	Y	31	
Columns:										
Dwell: NLT time - time received at LAWS rounded to nearest minute										
Weapon: Weapon fired										
Fire Time Source: The LAWS timeline event equated to the fire time: FRD=Fired report,										
WR=Fire When Ready command, OC=Fire On Call command.										
CE/LE: Circular Error/Linear Error. Mensuration accuracy reported in LAWS Targeting Information remarks.										
*0/0 and 100/100 indicates target not mensurated										
NLT- Fire time. The interval between NLT and the event listed in column 5 rounded to the nearest minute.										
Fire Cmd - LAWS: The time of the fire command - the time the nomination was received by LAWS.										
NLT Eval: NLT evaluation from Table 4. N = NLT not met, ? = uncertain if NLT met.										
Date: Experiment day in August from which data came.										

11. RPM Data.

A single RPM workstation located in JTASC generated routes for all the TLAM and TTLAM missions. The RPM workstation automatically logged the time a route request was received and placed in a queue, the time route processing was initiated, the time it was completed and the time the completed route was transmitted to LAWS. The raw RPM data, provided by Michael Weissenberger (Boeing), have been analyzed and the results are presented in the Table 10.

TABLE 10

RPM ROUTE GENERATION TIMES FOR MTO AND TST TARGETS
(times in seconds)

	MISSION TYPE	
	MTO	TST
NUMBER OF MISSIONS	9	12
NUMBER OF ROUTES	32	14
MEAN TIME IN QUEUE	233.9	4.2
MEDIAN TIME IN QUEUE	105	2.5
MEAN TIME TO COMPUTE ROUTE	87.3	75.2
MEDIAN TIME TO COMPUTE ROUTE	85.5	76
MEAN TIME -RECEIPT OF REQUEST TO TRANSMIT ROUTE	321.5	79.9
MEDIAN TIME - RECEIPT OF REQUEST TO TRANSMIT ROUTE	177.5	80

The mean time required to compute a route for both MTO and TST missions was 83.6 seconds. The dispersion was small as indicated by the minimum and maximum intervals were respectively 65 and 115 seconds. The total time required to process a mission was predominately determined by the time the route request had to wait for processing in the queue. This in queue interval reached as high as 960 seconds. This large value occurred on 28 August when three MTO missions, each requiring four TLAMs to be fired, were processed. The RPM work load was exacerbated by requests for extraneous routes. The C4IGW operator reported (LAWS IRC channel August 28, 10:02) that "RPM is getting MPRs for the same routes multiple times". As an example, MTO mission GS0038 consisted of four TLAM firings but RPM generated nine TTLAM routes. Thus, least a portion of the RPM workload was spurious. Nevertheless, it appears it is not difficult to overload, a single RPM workstation, capable only of sequential mission processing and, consequently, significantly extend engagement timelines. In a few cases (all Deyo or Ale engagements on Aug. 31), there were no routes generated for TLAM engagements.

12. Digital target Folders (DTF)

The function of the DTFs are to serve as a repository of all information relating to TSTs. In FBE H the DTFs received input from the following sources:

GISRC	ATI.ATR
JTW	ATI.ATR
BDA	Manual input
CAST	creates link to preexisting target data.

12.1. TST DTFs

In FBE H, 128 TST DTFs were created. Deleting those DTFs created prior to the start of the experiment (31), a total of 96 DTFs were created during Phase I of FBE H. This number includes the MTO targets nominated by the San Jacinto GISRC (4) and duplicate DTFs (16). Excluding those, there are DTFs for 82 nominated targets. This is very similar to the number of targets nominated in LAWS, but the targets in the two lists do not closely correspond. There are 46 target numbers in LAWS that do not appear in the DTFs and there are 21 target numbers in the DTFs that do not appear in LAWS. The latter figure further conforms the evidence of GISRC and JTW that not all nominated targets appear in LAWS.

12.1.1. Mensuration data

The DTF was to be automatically updated with the ATI.ATR message that JTW sent to LAWS and the DTF with the mensurated target coordinates. This did not appear to work reliably in that only 13 of the DTFs reported Desired Mean Point of Impact (DMPI) data.

12.1.2. BDA Data

BDA was manually inserted into the DTF by setting the Target Status field. There were four states displayed in this field: Active, under engagement, attack completed, and destroyed. For the 82 FBE H Phase I DTFs, the number of DTFs reporting each of the four BDA states is shown in Table 11.

TABLE 11
DTF TARGET STATUS

ACTIVE	24
UNDER ENGAGEMENT	18
ATTACK COMPLETED	16
DESTROYED	24
TOTAL	82

A comparison of specific nominations from LAWS and the DTFs indicates that the DTF Target Status is often not consistent with the LAWS engagement data. For example, in the LAWS data for 28 August there are six nominations which were not engaged but are listed as destroyed in the DTFs (GS0055, GM5020, GS0043, GS0044, GS0054, GS0037).

12.1.3 Data Time Tags

The DTF records the time the folder was created and the time of the last update. The DTF would be more valuable if each data element entered into the table were time

tagged. In particular, the DMPI data format provides a field named Time Mensurated but it was never filled.

12.1.4 Additional Data

The DTF is advertised as the repository of all relevant targeting data but there are many important gaps. There needs to be engagement data including: firing platform, weapon, time of fire, and impact time. Much more detail is required for BDA including time of BDA, source of BDA, and BDA sensor.

12.1.5 DTF Utility

The DTF folder was little used by FBE participants as a tool in the TST engagement process. This was in large part due to the inconvenience in accessing the DTF site for busy operators. Lack of DTF use presumably also owes something to the DTF data deficiencies described above.

12.2 Deliberate Target DTF

There were 289 DTFs for deliberate targets. After creation, these DTFs were never updated. They contain no BDA or mensuration data.

13. JSAF Data

In FBE H, none of the fire events for ERGM, LASM or TLAM for non virtual ships (e.g. San Jacinto and Deyo) were sent to JSAF. The San Jacinto and Deyo used ERGMs and LASMs to engage 77 percent of the TST targets. Accordingly, the great majority of TST weapons were not fired, flown out, or assessed in JSAF. The impact of this on the engagement timeline and, in particular, BDA is illustrated in Section 15.

14. MTO Missions

In FBE H, the LAWS Missions Coordination: Fires list contains some MTO missions in addition to the TST missions. The MTO missions, all assigned to the San Jacinto, were identifiable particularly on August 30 and 31 by remarks appearing in the LAWS Targeting Information identifying them as MTO targets. The other MTO targets were identified on the basis of the nominator (usually the San Jacinto LAWS) and the correspondence of the target location in the MTO with the target location reported in the LAWS Targeting Information.

Between August 28 and 31, 23 MTO engagements were assigned to the San Jacinto. Of those, 19 were nominated to LAWS by the San Jacinto LAWS or GISRC operators. Those that were not nominated lacked target positions in the MTO. Of the 19 targets nominated 11 were fired on. The reasons for engagement denial were listed in LAWS for

six of the eight targets that were not engaged, they included 4 RNG (range), 1 INT (intelligence), and 1 TIW (target in water). Other remarks in LAWS indicated the target positions were erroneous for the INT, TIW and one of the RNG missions. The MTO targets were not mensurated, this is explicitly stated in the LAWS remarks for some of the MTO targets (e.g. GS0038, GS0039, GS0040). Lack of mensuration is also indicated by the fact that the MTO target coordinates were almost always reported with zero seconds.

Operationally, the San Jacinto would fire its few MTO missions (from one to four) the first thing each day and then spend the rest of the day on TST targets. There was no interaction between the MTO and TST processes.

15. Data Latency

On August 31 Richard Tanner (INRI) made manual measurements of the interval it took for a track entered at the MTW or HST to appear on GCCS-M or C2PC displays at JTASC and vise versa. Fourteen observations produced intervals ranging from 1.8 to 9 seconds with mean and median of 3.9 and three seconds respectively. Although quantitative measurements were not made for other data latencies, a number of reports indicate that, at times, significant latencies existed for UAVSim video transmitted to GISRC and for communication of LAWS updates between the LAWS workstations. In constructing timelines for several engagements, in two cases (GH0209 and GH0210) it was found that it took more than 50 minutes for the nominations to reach LAWS and JTW from GISRC. Characterizing the magnitude and frequency of significant latencies in communications between systems in the DFN requires more complete electronic data capture by the various DFN systems and accurate time synchronization of those systems.

16. A Timeline Example

Table 12 presents a timeline for the engagement of target GM5032. This engagement timeline is comparatively complete and demonstrates the information potential of timelines. It also illustrates some of the problems the available data present in the construction of a complete and accurate timeline.

This mission was fired by the San Jacinto on August 31. The mission is listed in the LAWS Mission Coordination: Fires display as a LASM mission but the target was first engaged with a TTLAM and subsequently a LASM. Both weapons were fired under the same target number. LAWS does not retain timeline data for multiple weapons fired with the same target number. Both the TTLAM and LASM firings are reported in the LAWS Mission Coordination: TLAM display but, unfortunately, the fire times were not reported there.

The LAWS data indicate the target was mensurated but the JTW data were not collected on the San Jacinto and the San Jacinto JTW was not able to transmit ATI.ATR messages to the San Jacinto LAWS, accordingly, JTW timeline information is missing.

The timeline exhibits the following inconsistencies and problems:

1. The LAWS Timeline Report indicates the nomination was received at LAWS 45 seconds before GISRC reported it sent.

2. The San Jacinto LAWS smtp_out log indicates the Mission Planning Request (MPR) was sent to the RPM 139 seconds after it was received, as logged by the RPM, and 60 seconds after the San Jacinto LAWS smtp-in log indicates the completed route was received from RPM.

3. The RPM log indicates the route data were transmitted one second after they were received according to the San Jacinto LAWS smtp_in log.

4. The LAWS Timeline Fired Report for the LASM is time tagged about 20 minutes after the time of launch as indicated by the information in the San Jacinto observer log and IRC GISRC channel.

5. IRC and San Jacinto observer logs indicate the LASM was fired prior to 1400. TOF would only have been a few minutes but BDA did not occur until 1431. The need to manually impose target assessment and BDA (because the LASM firing was not sent to JSAF) required the UAV loitering in the target vicinity for about 30 minutes after the actual impact time.

The excerpts from the IRC GISRC channel that appear in Table 12, relate to the tasking of a UAV to obtain BDA for GM5032. The GISRC channel communications do not refer to a target number, only the target coordinates, accordingly the relevance of these data is circumstantial but they appear consistent with the timeline events.

TABLE 12

ENGAGEMENT TIMELINE FOR TARGET GM5032

TIME (hhmmss)	EVENT/REPORT	SOURCE
130005	ACQUIRE	MTW GISRC LOG
130027	NOMINATE	MTW GISRC LOG
130738	SEND	MTW GISRC LOG
130653	RECEIVED BY LAWS	LAWS TIMELINE
133322	MPR RECEIVED BY RPM	RPM LOG
133323	STARTED TO CREATE ROUTE	RPM LOG
133441	ROUTE RECEIVED FROM RPM	SAN JAC LAWS SMTP_IN LOG
133442	TRANSMITTED ROUTE TO LAWS	RPM LOG
133445	XMT OC FIRE COMMAND	LAWS TIMELINE
133541	MPR TO RPM	SAN JAC LAWS SMTP_OUT LOG
133730	TLAM ROUTE TO JSAF	MTW LAWS SMTP_OUT LOG
133833	INDIGO FIRING REPORT TO JSAF	MTW LAWS SMTP_OUT LOG
1338XX	FIRE TLAM, TOF 10 MINS.	SAN JAC OBSERVER LOG
1339XX	TLAM AWAY, TOF 10 MINS	IRC LAWS CHANNEL
1346XX	TLAM IMPACT, AWAIT BDA	IRC LAWS CHANNEL
135142	BDA= NO EFFECT, REENGAGE	LAWS COMMO LOG
1351XX	RETARGET, FIRE LASM	SAN JAC OBSERVER LOG
141628	FIRED REPORT	LAWS TIMELINE
1431XX	TARGET DESTROYED	IRC GISRC CHANNEL
TIME (hhmm)	**IRC GISRC CHANNEL COMMUNICATIONS (GM5032)**	
	(LAWS coordinates for GM5032 are 34 33 57.7N, 77 16 38.7 W)	
1329	<MTW_GISR2> #5, please investigate 34 39 56N/077 20 38W, possible movement/staging area	
1326	<MTW_GISR2> #5, what do you have?	
1338	<UAV_5-6> MTW-GISR, traffic in vicinity of 34 35N 77 17W, but looks all civilian	
1338	<MTW_GISR2> #5 can you fly closer for a better look	
1340	<UAV_5-6> roger	
1342	<MTW_GISR2> #5 need BDA on 3 sets of targets visited earlier vicinity 34 34N/ 077 15W	
1342	<UAV_5-6> roger, UAV5 going for BDA	
1346	<UAV_5-6> MTW-GISR, uav5 looking at previous targets vicinity 34 34N 77 15W	
1347	<MTW_GISR2> roger, negative BDA	
1348	<MTW_GISR2> #5 those targets will be reattacked.	
1349	<UAV_5-6> MTW-GISR, roger, standing by for BDA	
1354	<UAV_5-6> MTW-GISR, those targets remain undamaged	
1355	<MTW_GISR2> roger #5, stay on them	
1357	<UAV_5-6> uav5 keeps eyes on target	
1358	<MTW_GISR2> #5, San Jac and Deyo LASMs should be inbound	
1358	<UAV_5-6> roger, watching	
1404	<UAV_3-4> standby on BDA - these recent weapons all need manual eval - lots of concurrent evals now	
1407	<UAV_5-6>MTW-GISR, did you copy #3 message on manual BDA process? Bottom line, standby	
1430	<UAV_5-6> MTW-GISR, uav5 is still standing by, you should get some BDA soon	
1430	<MTW_GISRs> roger #5	
1431	<UAV_5-6> MTW-GISR, uav5 reports all 3 sets of vehicles destroyed vic 34 35N 77 15W	

17. Electronic Data Capture in FBE H

In FBE H, improvements were made in the collection and reporting of electronic data, particularly for GISRC and RPM. Much however, remains to be done particularly with regard to LAWS and JSAF which are central to the TST process in FBEs. Table 13 summarizes those events for which it was attempted, or would have been desirable, to collect data in FBE H, the success of the effort and reasons for lack of success. In addition to capturing the events and their associated data elements, the discussions in this document illustrates the problems with, and the importance of, the synchronization of the time stamping for all systems.

TABLE 13
ELECTRONIC DATA CAPTURE IN FBE H

SYSTEM	EVEN T	COLLECTED	SOURCE	REMARKS
LAWS	receipt of nomination	Y	LAWS Timeline	
LAWS	update latency	N		time required for update to be displayed at each LAWS node
LAWS	receipt of mensuration data	N		not in LAWS Timeline
LAWS	request TLAM route	Y	LAWS smtp_out logs	should be in LAWS Timeline
LAWS	receipt of TLAM route	Y	LAWS smtp_in logs	should be in LAWS Timeline
LAWS	TGT action	P	LAWS Timeline	not reliably present
LAWS	fire command	P	LAWS Timeline	not reliably present
LAWS	acknowledge fire command	N		not in LAWS Timeline
LAWS	fired report	P	LAWS Timeline	not reliably present
LAWS	TTLAM retargeting	Y	LAWS smtp_out logs	should be in LAWS Timeline
LAWS	estimated TOT	N		not in LAWS timeline
LAWS	NLT time	P	LAWS Targeting info	Dwell not entered for LAWS nominated targets. Should be in LAWS Timeline
JSAF	target injection	N		JSAF needs to be modified to log this event.
JSAF	target sensed	N		JSAF needs to be modified to log this event.
JSAF	target change of state	N		JSAF needs to be modified to log this event. Includes moving/stationary, hide/unhide
JSAF	weapon fire	N		majority of fire events not sent to JSAF. FBE AARS not operational
JSAF	weapon impact	N		majority of fire events not sent to JSAF. FBE AARS not operational
GISRC	receipt of target cue	N		not in GISRC logs. Require manual collection?
GISRC	cue follow up command	N		not in GISRC logs. Require manual collection?
GISRC	target acquisition	P	GISRC logs	data not complete for all platforms
GISRC	image latency	N		not in GISRC logs. Require manual collection?
GISRC	target nomination	P	GISRC logs	data not complete for all platforms
GISRC	transmit target nomination	P	GISRC logs	data not complete for all platforms
JTW	receipt of mensuration request	P	JTW logs	data not collected on all platforms. Not electronic, manually collected
JTW	transmit mensuration data	P	JTW logs	data not collected on all platforms. Not electronic, manually collected
JTW	time to mensurate	P	JTW logs	data not collected on all platforms. Not electronic, manually collected
RPM	receipt of route request	Y	RPM logs	
RPM	transmit route request	Y	RPM logs	
RPM	time to calculate route	Y	RPM logs	
CST	track latency	P	manual log	CST electronic logging not employed. Data consist of a few manual observations
IRC	communications	Y	IRC logs	Time tagged chat channels to integer minutes. Need time tag to integer seconds
		P = partial		

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